British
Phycological Bulletin

No. 7

JULY 1959

Issued by
The British Phycological Society

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THE BRITISH PHYCOLOGICAL SOCIETY

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BRITISH PHYCOLOGICAL BULLETIN

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Honorary Editor:
Elsie Conway,
Department of Botany,
University of Glasgow.

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EDITORIAL NOTE

Earlier numbers of this journal have carried the title of **Phycological Bulletin**; but with this number, the title is changed to **British Phycological Bulletin**. This change is made by a decision of the Council in order that there may be no risk of ambiguity when the journal is referred to in literature lists or when, as is anticipated, it appears in the next edition of the World List of Scientific Publications. Authors and others referring to the journal are, therefore, in future asked to use the abbreviations **Brit. Phyc. Bull.**

BUOYANCY IN RELATION TO THE ECOLOGY OF THE FRESHWATER PHYTOPLANKTON *

by
J. W. G. LUND
Freshwater Biological Association, Ambleside.

When considering what would be a suitable subject for my presidential address I at first thought that a review of the ecology of the freshwater algae would be valuable. However I soon came to the conclusion that, even if I confined myself to planktonic algae, the subject was too large to be treated satisfactorily. I finally decided that I might perform a more useful service if I considered some aspect of the ecology of phytoplankton which mystifies me and, maybe, others as well. I hope that as a result I may stimulate some research on these matters. Now it so happens that our society has always had a high proportion of relatively young members and it is to them that my remarks are especially directed, for it is they who are going to make the major advances of the future.

If we ask which are the environmental factors which prevent us from the pleasure of seeing the water of some familiar lake looking like brown soup through the mass development of diatoms, we may be told that the answer is obvious, namely, lack of nutrients. Indeed, in the case of a lake with which I am familiar, Windermere, I have produced some evidence to support this view in so far as the spring 'flowering' of diatoms is concerned (Lund, 1950). It is not for me to judge this work but, even if it is correct, it is of little help in understanding the ecology of plankton algae as a whole or indeed of diatoms, for there is a vast number of lakes in which the populations of diatoms are so small and the concentration of dissolved silica so high that one cannot believe that there is any relationship between this nutrient and their periodicity (e.g. Lund 1957, figs. 2, 3). Indeed the diatoms are so few that it is impossible to determine what nutrient, if any, controls their growth. Even in Windermere, if we pass from diatoms to other kinds of algae we are unable to do much more than guess which factors hinder the production of visible blooms. It is, of course, reasonable to suspect again that the major factor is the small amount of nutrients available, for those which we can cultivate in the laboratory will proliferate in the nutrient solution until the culture vessels are discoloured by the millions of cells within. When we consider which are the nutrients limiting the crop of any alga in nature, we find that the possibilities are large, and, unfortunately for the ecologist, the physiologist steadily adds to their number. Nevertheless we should not ignore some other factors which may seem a great deal easier to study such as grazing, parasitism, light, temperature and buoyancy.

Buoyancy is largely taken for granted yet it seems to me that it is worth considerable attention. A successful plankton alga, if it cannot swim, must have a relatively slow rate of sinking. Even if it can swim this may well be true, if to a lesser degree, for otherwise a large amount of the energy available will be dissipated in keeping within or returning to the photic zone. If the water is shallow enough the whole will be within the photic zone and, if thermal stratification be absent, as it often is in such waters, any unattached cell may be in suspension for a shorter or longer period. This is one reason why algae considered as normal components of the plankton of pools are so rarely found in that of lakes, although emphasis is

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* The third presidential address, presented to the British Phycological Society on January 2nd 1959.

often laid on differences in the chemistry of the water, a factor which, of course, should not be ignored. Species of the ubiquitous genus *Scenedesmus* provided an example. They would appear to be well adapted for planktonic life. The colonies are flattened and plate-like, often spinous as well. They are practically never observed in the plankton of lakes as large and deep as Windermere. However they are by no means uncommon on the littoral deposits (fig. 1). It is easy to think of other examples such as the large incised discs of *Micrasterias rotata* (Grev.) Ralfs. and *M. denticulata* Breb. It would therefore be useful if one could study their rate of sinking before embarking on biochemistry. Yet, if we say that if an alga cell sinks too quickly it cannot form part of the plankton, we may forget to ask the really important question which is: what is too fast? There is no absolute answer to this; for example the success of *Melosira* spp. such as *M. italica* subsp. *subarctica* O. Müll (Lund, 1954, 1955) shows that the disadvantage of a relatively high rate of sinking may be offset by other features which enable it to compete with other diatoms. But even this alga must remain in suspension for considerable periods of time over a large part of the year in order to do so.

Figure 1.

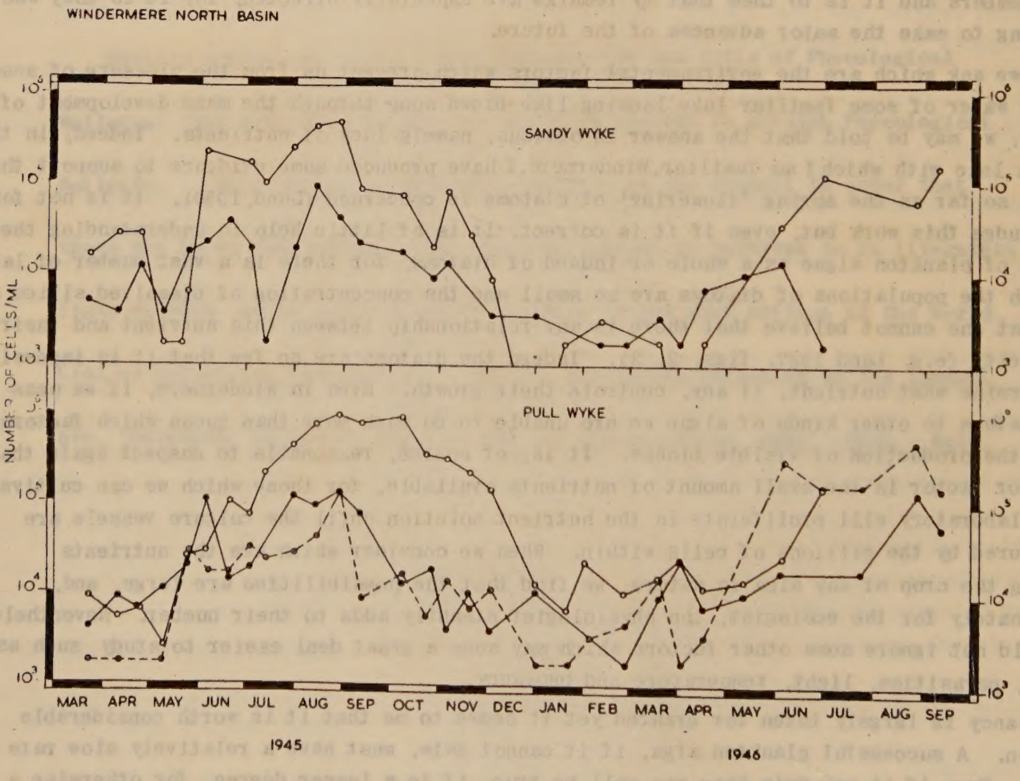

Fig. 1.

Seasonal changes in the abdunance of *Scenedesmus* spp. on the underwater soils in two bays at the northern end of Windermere. The macrophytes in each area were as follows, the type of circle in the line of the graph concerned being given in brackets. Sandy Wyke, *Phragmites communis* Trin. (white) and *Lobelia dortmanna* L. (black); Pull Wyke, *Schoenoplectus lacustris* (L.) Palla and *Equisetum fluviatile* L. (black); *Sparganium minimum* (Hartm.) Fr (white with central black dot and broken line), and *Phragmites communis* Trin. and *Carex rostrata* Stokes (white).

The morphology of many plankton algae has often been related to the mechanics of flotation, though the examples of *Scenedesmus* and *Micrasterias* just quoted show that a large ratio of surface area to volume may serve some quite different purposes. Mounting these algae in Indian ink sometimes shows that their shapes have no apparent relation to flotation because they are enveloped in mucilage (e.g. many planktonic desmids). Indeed one of the advantages of being so surrounded may be the decreased specific gravity conferred on the alga thereby. Further the very features which may help mechanically to retard the rate of fall also often confer on the cell a relatively large ratio of surface area to volume. This may be of greater value in the absorption of nutrients or even in reducing the chances of ingestion by animals.

In view of the vital importance of flotation one might expect that much would be known about the rate of fall and the weight of freshwater algae in water. Yet I am not convinced that there is any trustworthy published figure for either. There are considerable technical difficulties. Moreover we need to be able to relate any data we obtain to water movements in nature. This is a problem in physics and mathematics which is largely unsolved.

According to Gross and Zeuthen (1948) marine plankton diatoms "under suitable physical conditions do not sink because their specific gravity is equal to that of sea water". In *Ditylum brightwellii* this buoyancy is probably attained by the maintenance of a very low ratio of divalent to monovalent ions, for a solution of monovalent ions, such as Na and Cl, isotonic with seawater has a markedly lower specific gravity than one in which divalent ions preponderate. Now I am not competent to comment on their work but, in reading it, it struck me that since it is the specific gravity of silica which is the main factor to be overcome, it may be doubted whether such a mechanism can be effective unless the diatom concerned has a relatively thin or weakly silicified wall, or a large ratio of cell to wall volume. These conditions may be met in *Ditylum* but are they in *Asterionella japonica?* The proof of their theory can only be obtained by analysing the cells, and here we have another example of a great lack of essential fundamental knowledge. Since we now possess techniques for collecting large quantities of algae or for growing them and for their elementary analysis, it is a great pity that so few such analyses have yet been made. However, I am concerned with freshwater algae and here this mechanism can scarcely be invoked because of the small quantity of salts in solution. For example, Windermere water (circa 33 mg/1 total ions), which is similar in ionic constitution to that of many softwater lakes, has a density only 0.003% greater than water itself. This may be compared with seawater (circa 33000 mg/1 total ions) which is about 2% denser than water. Moreover very few of the plankton diatoms are weakly silicified and the ratio of weight of silica to cell volume is generally relatively high(e.g. Einsele and(Grim) 1938 tables 2, 3 and unpublished data). Yet it is true that some are sometimes seen to be in suspension in unshaken cultures, and of those familiar to me *Asterionella formosa* Hass shows this feature most often. Nevertheless it is my belief that these diatoms never have the same density as the medium in which they live, so that they do sink. It is not clear that even Gross and Zeuthen (1948) found that *Ditylum* did not sink in the absence of water movements, though their whole thesis is based on this belief.

TABLE 1

SOURCE OF MATERIAL (LAKE OR CULTURE)	MEAN RATE OF FALL (SECS. PER UNIT DEPTH)		RANGE IN RATES OF FALL		NO. OF COLONIES TIMED	
	ASTERIONELLA	*MELOSIRA*	*ASTERIONELLA*	*MELOSIRA*	*ASTERIONELLA*	*MELOSIRA*
CHAMBER *A*						
Haweswater, March 12th	309	61	117-726	28-114	11	11
Blelham Tarn, March 15th	371	81	224-485	50-94	15	4
Windermere, March 20th	185	52	81-355	43-61	25	2
Windermere, March 24th	498	-	128-880	-	11	-
Windermere, April 7th	251	-	124-454	-	6	-
Culture, exponential phase	220	-	70-480	-	13	-
	306	65	70-880	28-114	81	17
CHAMBER *B*						
Haweswater, April 15th	-	133	-	37-278	-	26
Ullswater, April 16th, morning	-	167	-	67-591	-	21
Ullswater, April 16th, afternoon	-	215	-	76-495	-	4
Culture, not exponential	-	180	-	58-325	-	8
Culture, post exponential (25000 cells/ml)	496	-	287-1234	-	48	-
Culture, exponential (6500 cells/ml)	696	-	205-2402	-	26	-
	596	174	205-2402	37-495	74	59

TABLE 1. Rates of fall of colonies of *Asterionella formosa* Hass. and *Melosira italica* subsp. *subarctica* O. Müll in constant temperature (0°C) chambers. In chamber *A*, the distance between two horizontal cross-wires over which measurements were made was 0.68 mm.; for chamber *B*, this is not known. The work was done in 1952.

Mr F.J.H. Mackereth and I have made some preliminary observations on *Asterionella formosa*, *Fragilaria crotonensis* Kitton, *Tabellaria flocculosa* var. *fenestrata* (Kütz) Knuds and *Melosira italica* subsp. *subarctica*, all of which point to their having positive rates of fall in water. In table 1 the comparative rates of fall of *Asterionella* and *Melosira* are given. The algae were placed in a chamber lying within a vacuum flask and kept at 0°C. As might be expected *Melosira* (circa 10 µ per sec.) sinks much faster than *Asterionella* (circa 2 µ per sec.). Some of the populations were obtained from Windermere immediately before placing in the chamber, while others were from cultures in the exponential phase of growth. It is always the case that when samples of plankton are left to stand in the laboratory, the diatoms sink more or less quickly. Further Mr F.J.H. Mackereth, using a diver technique, as Gross and Zeuthen

Figure 2.

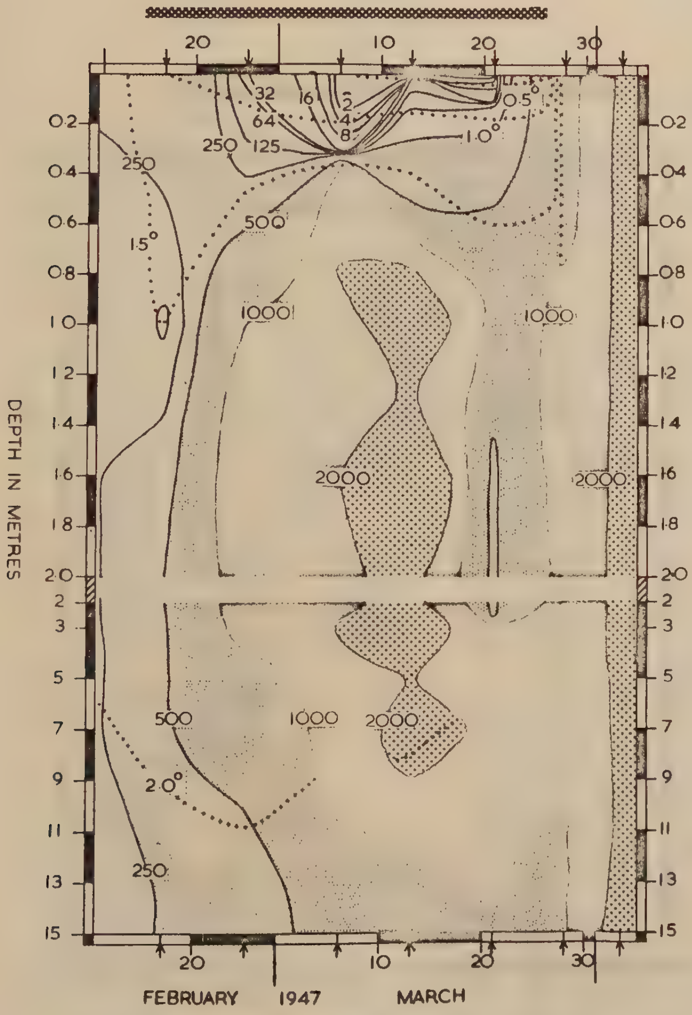

Fig. 2.

Depth-time diagram of the abundance of *Asterionella formosa* Hass. in the area of deepest water in Esthwaite Water from February to April 1947. Period of ice cover indicated by the horizontal cross hatched column at the top of the figure. **Dotted lines**, isotherms at 0.5°C intervals; **continuous lines**, isopleths of cells per ml. The vertical scale of depth is in two parts, the upper from 0 - 2 m. and the lower from 2 - 15 m. respectively, because the most marked stratification in temperature and algal density was just below the ice sheet. Sampling dates indicated by arrows below the base line of the figure.

(1948) did, has found that the weight of an *Asterionella* cell in water is almost exactly that which it would be expected to have from its known content of silica (Lund, 1950, p. 22, table 3). Lastly, under ice cover *Asterionella* populations sink as figs. 2 and 3 and table 2 show, and again comparison with my data (Lund, 1954) for *Melosira italica* subsp. *subarctica* shows that, for the same lakes in the English Lake District over the same period, the rate of fall is much greater. Now Gross and Zeuthen (1948) stress that marine diatoms can also be observed to sink at times but say that this only applies to "physiologically damaged" cells. It is odd if, in all our observations and experiments, the cells were in this state. Indeed I would go so far as to say that this is most unlikely.

Figure 3.

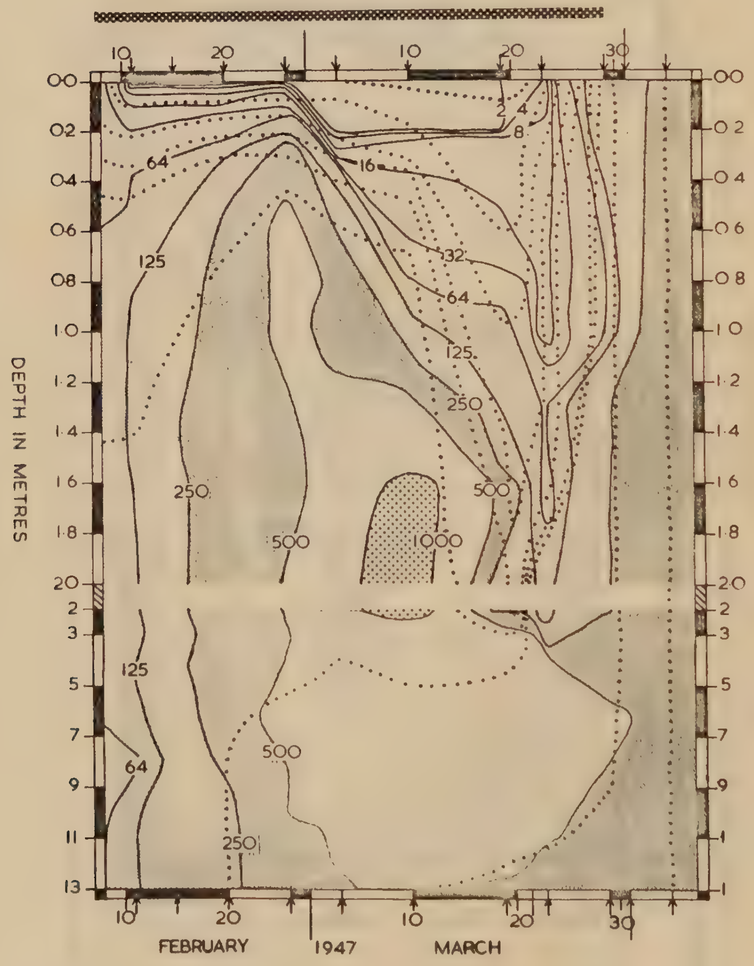

Fig. 3.

Depth-time diagram of the abundance of *Asterionella formosa* in Blelham Tarn from February to April 1947. For explanation see fig. 2.

TABLE 2

Basin	North	South	South	South	South	South
Date	March 5	Feb. 28	March 5	March 6	March 17	March 27
			cells per 25 ml.			
Depth(m.)						
0	8	15	0	-	0	3930
0.1	96	37	50	-	1	-
0.2	252	435	625	-	146	-
0.3	442	900	625	-	572	-
0.4	473	1200	2138	-	1758	-
0.5	407	1303	2820	-	2585	-
0.6	407	1248	1522	-	2595	-
0.8	493	1279	1925	-	3270	-
1.0	-	1413	2333	-	4145	4625
2.0	-	1851	2818	-	3605	-
3.0	-	1707	2938	-	3775	3930
4.0	-	2146	2735	-	3515	-
5.0	-	1398	1769	1895	2910	-
0-5 column	455	-	-	1300	3258	4200
6.0	-	-	-	-	-	3790
10.0	-	-	-	1458	3530	-
12.0	-	-	-	-	-	4105
15.0	-	-	-	2042	-	-
20.0	-	-	-	1260	1985	3925
25.0	-	-	-	1270	-	-
30.0	-	-	-	-	3180	3915
33.0	-	-	-	-	3320	-
33.7	-	-	-	-	3730	-
33.9	-	-	-	-	2465	-
36.3	-	-	-	-	-	4170

Table 2. Distribution of *Asterionella formosa* during the period of ice cover and afterwards in Windermere North and South Basins. Ice cover only complete in South Basin where it began on February 22 and ended approximately March 22. The samples in the South Basin were not all taken at the same station because of the difficulty of sampling through thin ice. Samples of 0-5 m.column taken with rubber hose, others with Friedinger water bottles or technique described in Lund (1954).

Those Myxophyceae whose cells contain gas vacuoles are generally thought to be lighter than water, and anyone who has watched water blooms developing in quiet weather and breaking up in a breeze will be convinced that their behaviour in a bottle in the laboratory, where they usually rise to the top, is normal, even though Gross and Zeuthen (1948) may be right in believing that that of diatoms is not. The distribuion of *Anabaena circinalis* Rab. ex Born. et Flah. in Esthwaite Water during a period of hot weather in 1955 (fig. 4) is characteristic of several species and suggests that the cells are lighter than the water so that it is only turbulence which stops them from forming a scum on the surface. However such Myxophyceae are not always so buoyant.

Figure 4.

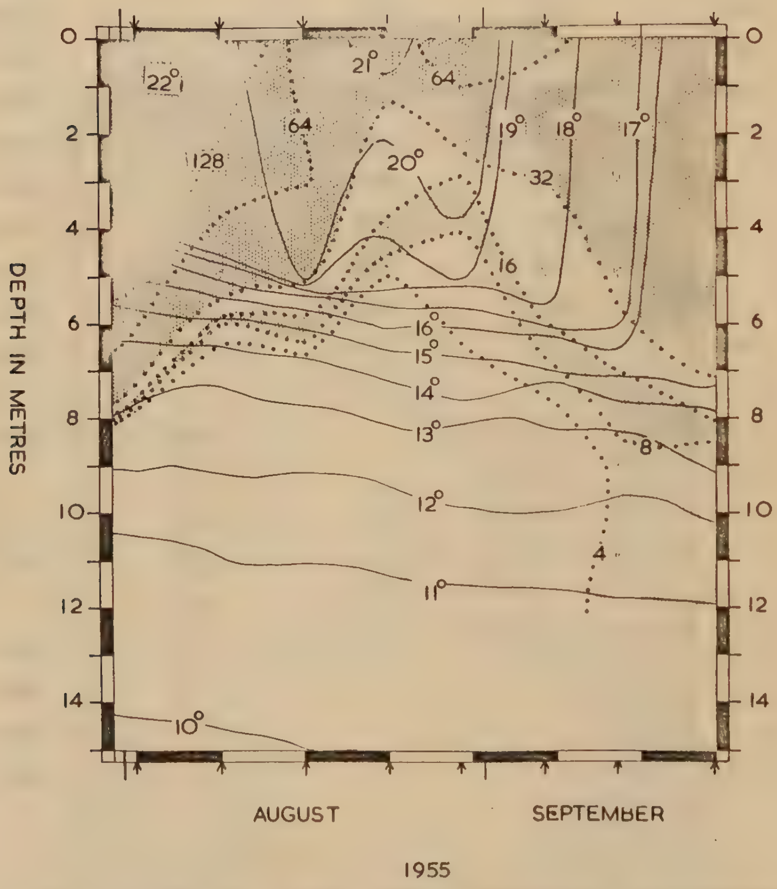

Fig. 4.

Depth-time diagram of the abundance of *Anabaena circinalis* Rab. ex Born. et Flah. in Esthwaite Water in the area of deepest water during a period of hot weather followed by the beginning of the autumnal breakdown of stratification in 1955. **Continuous lines**, isotherms at 1°C intervals; **broken lines**, isopleths of threads per ml. Sampling dates indicated by arrows.

Figure 5 shows the distribution of *Oscillatoria agardhii* var. *isothrix* Skuja in the same lake during the same period of strong thermal stratification. The cells of both species contain several pseudovacuoles. There may be several reasons why *Oscillatoria* is so abundant in and around the metalimnion but one may well ask how an alga with vacuoles containing gas can maintain its position there. That this *Oscillatoria* is not always lighter than water is shown also by its distribution under ice (table 3). In this case the depth of the water column is such that there can be no doubt that the cells in the lower parts are below the level at which they can grow through photosynthetic activity. Similar types of distribution are recorded for the famous Burgundy Blood alga, *Oscillatoria rubescens* D.S. (e.g. Thomas, 1949, 1950).

Figure 5.

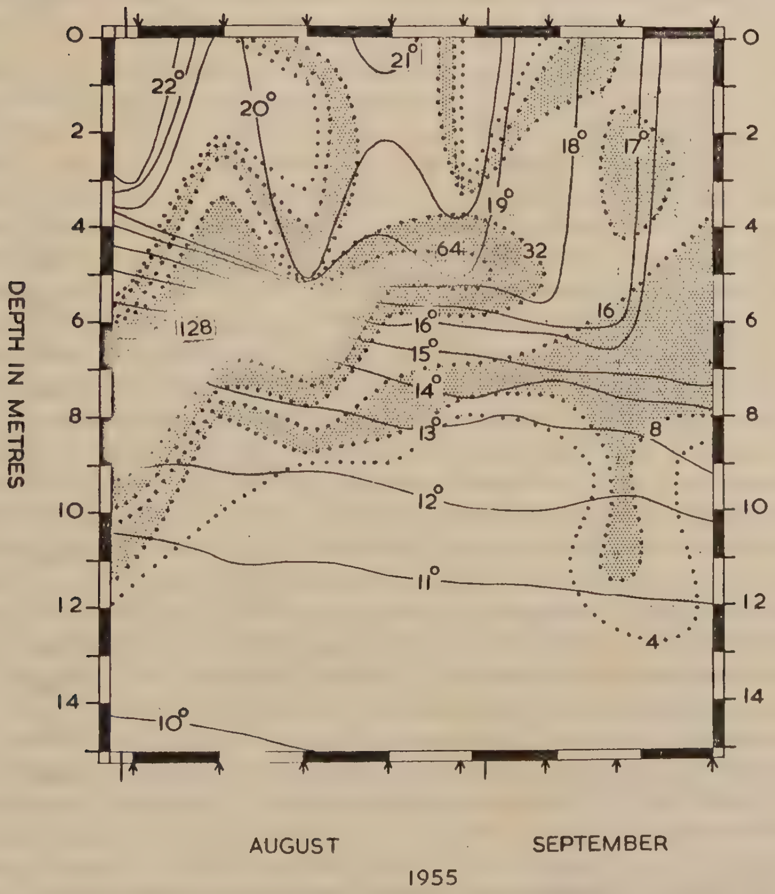

Fig. 5.
Depth-time diagram of the abundance of *Oscillatoria agardhii* Gom. var. *isothrix* Skuja in the same area of Esthwaite Water over the same period of time as in the case of *Anabaena circinalis* illustrated in figure 4. The method of construction of this figure is also the same as that of figure 4.

TABLE 3

Date	Feb. 28	March 5	March 6	March 17	March 27
	cells per 25 ml.				
Depth(m.)					
0	-	15	-	22	90
0.1	-	25	-	13	-
0.2	44	30	-	34	-
0.3	58	41	-	41	-
0.4	-	110	-	75	-
0.5	73	163	-	83	-
0.6	-	105	-	68	-
0.8	-	117	-	-	-
1.0	-	160	-	-	-
2.0	-	121	-	165	-
3.0	-	162	-	120	65
4.0	-	-	-	145	-
5.0	-	125	93	163	-
6.0	-	-	-	-	45
10.0	-	-	172	-	-
12.0	-	-	-	-	70
20.0	-	-	-	195	-
25.0	-	-	130	-	-
30.0	-	-	-	155	75
33.0	-	-	-	300	-
33.7	-	-	-	295	-
33.9	-	-	-	490	-
36.3	-	-	-	-	65

Table 3. Distribution of *Oscillatoria agardhii* var *isothrix* Skuja during the period of ice cover and afterwards in Windermere, South Basin, 1947. Ice cover began on Feb. 22 and ended approximately March 22.

In each case illustrated here it will be seen that when stratification weakens (September) and turbulence becomes effective to greater depths the stratification in algal numbers also becomes less marked.

Another problem which needs solving is how plankton algae are oriented under natural conditions. The *Oscillatoria* and the diatoms we observed in a constant temperature chamber were so oriented that they presented the least surface area to the vertical axis of the water column, and so to the direction of fall and of gravity. This suggests that the usual accounts in text books (e.g. Ruttner, 1953 p. 98) may need emendation. Now if they are, in nature, surrounded by non-turbulent water, as it seems may be the case, they are oriented so that the structural features which would exert a strong brake on the rate of the fall cannot do this. Nevertheless the small water masses in which they lie are themselves in turbulent motion or are parts of large ones which are. Then, as these masses are moved about, the position of the algae will be continually changing with reference to the direction of gravity, and the importance of their shape, or form-resistance as Oswald (1902) calls it, will depend on how long it retards their becoming re-oriented into the position they must take in the non-turbulent water immediately surrounding them. This matter is also important in relation to nutrient absorption which I shall discuss later, for it permits of horizontal movement.

It is possible that the chance of an alga being lost to the epilimnion in summer may depend a great deal on the degree of turbulence, even when it is above the minimum necessary to keep them suspended when well within the isothermal zone itself. The vital factor may be how frequently and for how long on the average an alga is brought into the zone of reduced water movement marking the transition from epilimnion to metalimnion. It is when they are in this region that their specific rates of fall will determine whether or not they pass into the thermocline and so into the hypolimnion below. One thing seems certain and that is that a cell is much more likely to be lost to the photic zone in summer under stratified conditions than in winter, if ice-cover be absent. This is because, under unstratified conditions, turbulence reaches to all depths and at times into the semi-liquid superficial mud (e.g. see the data for *Melosira* in Lund, 1955 and Gorham, 1958), so that a cell situated at any depth has a good chance of being returned to the upper layers. From this we might infer that most of the plankton algae which flourish in the epilimnion in summer would sink more slowly than those flourishing under isothermal conditions. So far as *Melosira italic subarctica* is concerned this is true but for a number of other algae laboratory observations suggest the reverse. Thus several planktonic Chlorococcales and desmids, as well as *Fragilaria crotonensis* Kitton, sink faster than *Asterionella*, though this last diatom alone has its main development under isothermal conditions and, in the lakes concerned, rarely produces large populations in conditions of direct thermal stratification. We have, of course, to bear in mind that, as is not uncommonly the case, the behaviour of these algae under laboratory conditions may not be the same as under natural ones. Yet further, if we take the view that diatoms and many other algae, such as non-motile colonial and unicellular Chlorophyceae, do have a positive rate of fall in water, then it follows that if the rate of multiplication is slow enough the population will be lost to the epilimnion in summer. Thus what might be suspected to be a decrease from a lack of nutrients or grazing may simply be the result of a rate of loss by sinking which is greater than the rate of gain by growth. This is exactly what is seen under ice in a population of *Asterionella* (figs. 2, 3) or in one of *Melosira* then or under direct thermal stratification in summer (Lund, 1954, 1955).

A similar form of physical control of growth which again might easily be misinterpreted is seen in Gran and Braarud's (1935) statement that production cannot exceed destruction if the mixed upper layer is more than a certain depth. The relation between this critical depth and the onset of the spring increase in marine phytoplankton has been considered further by

Riley (1942) and Sverdrup (1952). There can be no doubt that it is this relationship which is responsible for the remarkably similar timing year after year of the start of the spring development of diatoms in certain lakes of the English Lake District. The depth of this mixed layer is a function of temperature and turbulence. Thus in mid-winter there is no significant increase because the mixed layer is so deep that most of the cells are not in the photic zone long enough to increase sufficiently to ensure that the losses in the population as a whole are less than the gain by growth. If, however, ice is formed and remains free of snow the mixed layer becomes so shallow that an increase does take place so that there are numerous records of plankton development under ice. This we saw too in the figures 2 and 3 of the development of *Asterionella* under ice, though if snow falls and the sinking rate is great enough the growing population falls to levels where light is insufficient for further growth. The degree of turbulence alone may play a vital part, as Sverdrup (1952, p. 290) points outs. "A phytoplankton population may increase independently of the mixed layer if the turbulence is moderate. In this case the plankton may be unevenly distributed at the end of the daylight hours, with greater concentration above the compensation depth where production has taken place. During the night hours mixing may not be complete and when daylight again makes photosynthesis possible, the concentration of plankton may still be greater near the surface". If this condition lasts a major increase can take place. Here again we see that while a certain degree of turbulence is advantageous in assuring the suspension of the algae, a further increase may be harmful. This relationship will obviously apply at any time of year. Since I am concerned with freshwater algae it is necessary to add that most lakes are not deep enough for this relationship with a vertical depth to come into play once the winter is past, for there is usually a compensatory factor in deep lakes and that is that they have clear water so that the photic zone is deeper than in shallow ones.

Everything I have considered so far, preliminary and limited though the data may be, makes one thing abundantly clear. We know very little about the only characteristic feature of all planktonic algae. However, there is yet enother aspect of flotation which we ought to consider. So far we have had as a background the view that perfect flotation or a density equal to that of the surrounding medium is a desirable property. Yet it is quite likely that this is not the case under most conditions.

Munk and Riley (1952) in a paper of great interest have pointed out, with special reference to marine diatoms, that absorption of nutrients in unit time will be increased by an increase in the rate of sinking. If this is so, and Gross and Zeuthen (1948) are correct in saying that marine plankton diatoms if they are not "physiologically damaged", have a density equal to that of sea water, then this adaptation for flotation is disadvantageous so far as nutrition and growth are concerned. The rate at which a nutrient in solution can be transferred depends both on the dimensions of the alga and the physical characteristics of the surrounding fluid. It will be much faster if the fluid moves past the plant and so continually renews the nutrients in the impoverished zone around it than if there is no such relative motion. If the algae are in the photosynthetic zone then it follows that the rate of growth will be faster also. The effect of the moving water is designated "forced convection", as against diffusion when there is no such motion. It may then be an advantage for the specific gravity of the cell to increase. Munk and Riley (1952) point out that in experimental cultures nutrient depletion is commonly accompanied by an increased sinking rate, a feature which may be true of some freshwater diatoms though as usual we have no trustworthy facts. They say further that this may be so in the sea at the end of a period of flowering, so that this may be a self-regulatory device, accumulation of storage products increasing the specific gravity and so the sinking rate and the rate of nutrient absorption. Of course, if the rate of sinking becomes too great the cells will pass out of the photic zone before they have time to utilise the nutrients, but so far as freshwater diatoms are concerned this may be advantageous at this time. It appears that if *Asterionella* (Lund, 1950; cf. also Talling, 1957 p. 42) is illuminated in the absence of sufficient amounts of certain nutrients, for example silica, photosynthesis and growth continue until the cellular mechanism breaks down and death follows. This is why the spring maximum is succeeded by a catastrophic decline in numbers. Cells not in the photic zone remain alive. Here then, apparently, is a situation in which the faster the alga sinks the better. It is also an example of the fact that if one is to be an ecologist one must continually try to visualise just what is happening in nature and always realise that any fundamental data obtained in the laboratory may have more than one kind of ecological significance, even to the extent of exerting a positive effect over one period and a negative one over another. However Munk & Riley (1948, p. 224) and I are referring specifically to diatoms and I am not convinced that their attractive hypothesis is correct, for they say "there may be an increase in specific gravity due to the accumulation of storage products that cannot be used for reproduction because of nutrient deficiency". But in diatoms these are commonly fatty substances which far from increasing the specific gravity will do the reverse. We should perhaps pay more attention to their carbohydrate (e.g. leucosin) content. The accumulation of these substances under such conditions is widespread in small algae (Fogg & Collyer 1953). Further, in freshwater, most of the planktonic diatoms producing large populations are colonial. A well known characteristic in the development of such populations in nature and in laboratory cultures is that at first the number of cells per colony is large but as chemical conditions become unfavourable the

Figure 6.

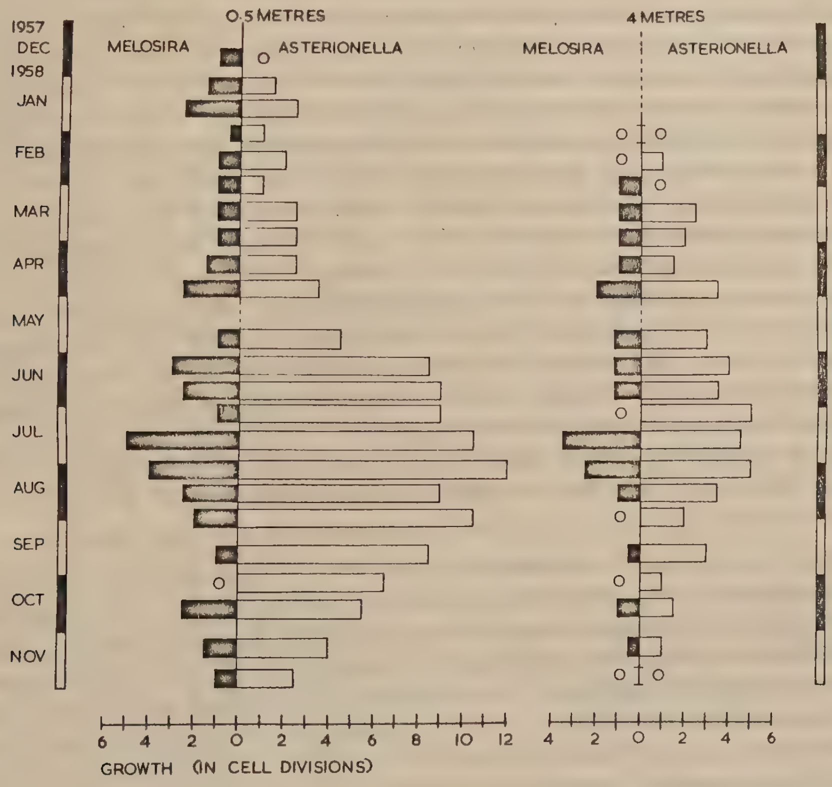

Fig. 6.

Growth of unialgal cultures of *Asterionella formosa* and *Melosira italica* subsp. *subarctica* in Pyrex bottles suspended at two depths in Windermere, South Basin. Culture solution, no. 10 of Chu (1942) with 0.2% alkaline extract of Windermere profundal mud. Cultures exposed for 7 days and growth expressed on a cell-division basis. *O*, less than one cell-division. Broken line, no samples.

number decreases (for *Asterionella* see Wesenberg-Lund, 1900; Gardiner, 1940-41; Pearsall, Gardiner & Greenshields, 1946). Thus at the end of a period of flowering the size of the colony decreases but the shape does not alter fundamentally. Therefore the rate of sinking will decrease unless the colonies contain appreciable numbers of dead cells. In the latter case the evidence available for *Asterionella* (unpublished observations in prep.) suggests that the rate becomes so fast that the colonies rapidly fall out of the epilimnion. Wesenberg-Lund (1900) indeed held that the predominance of few-celled colonies of *Asterionella* in summer was a reflection of their slower rate of fall than the larger winter ones.

Melosira italica subsp. *subarctica* might perhaps be expected to grow relatively fast because its rapid rate of fall will lead to the possibility of a relatively high rate of nutrient absorption. Nevertheless such evidence as we possess at present points to the reverse being the case. Unfortunatly we cannot compare it with another diatom of cylindrical shape but it is possible to compare it with that of those whose shapes approximate more or less closely to the discs and plates considered by Munk & Riley (1952). We then find that it grows more slowly than *Asterionella formosa, Fragilaria crotonensis* and *Tabellaria flocculosa* var *asterionelloides* (Grun. in V.H.) Knud. Figure 6 shows its increase by growth expressed on a cell division basis, in cultures suspended at one and four metres below the surface in Windermere compared with that of *Asterionella* which grows the fastest of these four diatoms. Nevertheless before we accept this as an example which does not conform to Munk and Riley's general hypothesis we should remember that in a bottle suspended at one depth for 7 days the very factor concerned, namely rate of fall, may be so limited that the diatom is being kept under very unfavourable conditions. Moreover keeping the cells at one depth for so long is unnatural. I emphasize these points particularly because again it shows how careful we must be about extrapolating the results obtained under more or less artificial conditions into natural ones. Indeed it would have been possible to have devoted the whole of my presidential address to examples of erroneous ecological theories erected on work with laboratory cultures. This might have been of value, it might even have caused some mirth, but it would, in my view, have been a dangerous theme, for it could have given the impression that laboratory experiments are of little value. Exactly the reverse is the case. We shall never understand the ecology of algae without a vast amount of cultural work. We must, however, combine this with observations on populations in nature. To return to *Melosira*, there are reasons for believing that it does grow slowly. One is that there are sufficient nutrients in the culture solution (No. 10 of Chu, 1942, with soil extract) to produce populations far in excess of those produced in these experiments. Another is that larger populations have been produced in the laboratory at greater rates of growth without agitation. To ensure, so far as possible, that there should be no significant utilisation of nutrients in the cultures exposed in the lake, the inocula used were kept low enough to ensure that the population at the end of the experiment did not exceed 2000 cells per ml; in most experiments it was less than 500.

In freshwater, in contrast to the sea which Munk & Riley were considering, the Myxophyceae with pseudo-vacuoles play a big part in the plankton. Now obviously "forced convection" will apply regardless of the direction in which an alga is moving and the consequent possibility of pseudo-vacuoles being of biological advantage in increasing the rate of nutrient absorption does not appear to have been considered. Gas vacuoles are generally considered as advantageous purely for the buoyancy conferred on the alga, although other possibilities have been suggested, such as that they act as a light screen or even that they are a by-product of metabolism under anaerobic conditions and perhaps indicate that the cells are in an unhealth state (for reviews about them see Fritsch, 1945, pp. 772-775 and Fogg, 1941). If it is correct that these forms first develop pseudo-vacuoles when on the bottom deposits, so that they are only secondarily planktonic, then we have a superlative arrangement for "forced convection". Yet all my own experience leads me to doubt this but, as with almost every topic I have discussed, we need facts not mere impressions. In the species I am familiar with it is rarely possible to find more than a minute proportion of the cells without pseudo-vacuoles. This is certainly evidence against this theory but we need a thorough examination of profundal deposits. It is odd that despite the vast literature on these algae there is no comprehensive observational account of their seasonal periodicity and distribution throughout the whole of a body of water. Such an investigation should, for some species at least, prove conclusively whether the production of gas vacuoles takes place at or near the bottom of a lake.

A final problem raised by Munk and Riley, which I would like to consider concerns grazing. This may seem to be going beyond the title of this address but in fact they relate this problem directly to flotation because their results "indicate an inherent competitive advantage of small diatoms over big ones". They ask why the larger species of marine diatoms are able to compete with the smaller ones which possess advantages both in flotation and the absorption of nutrients. They suggest that predation is a possible explanation. They point out that it is true that a copepod such as *Calanus finmarchicus* feeds effectively on large diatoms but never-the less "it seems likely that the small animals which constitute the major bulk of the zoo-plankton population would have definite limits as to the size of the food they encompass" (Munk & Riley, 1952, p. 228). This is true of freshwater algae to an even greater degree because, in the temperate zone at least, there is no equivalent to *Calanus*. Indeed grazing is a great unsolved problem of freshwater ecology and could also have served as a subject of this address. There is a large literature on the subject, scattered here and there, but it is impossible to obtain any clear idea of what the real position is (for a review see Edmondson, 1957). I have never found any evidence that the larger planktonic freshwater algae are grazed upon to any appreciable extent. This is the most striking difference I know of between the ecology of marine and freshwater plankton. It is well known that many planktonic animals have filter feeding mechanisms which will not permit the entry of such relatively large particles. There is, however, at least one clear exception to this, namely the large rotifer *Asplanchna priodonta* which often ingests large algae such as *Coelosphaerium, Asterionella* and *Tabellaria*. It seems, therefore, extraordinary that this rotifer does not produce vast populations during the large maxima of these and other plankton algae which frequently arise in the lakes it inhabits. Once again there is no quantitative data to support this statement so that we cannot be sure it is correct. Carlin's (1943 Abb 60 and 94) data for the periodicity of this rotifer and *Asterionella* show a marked similarity, though no quantitative relation can be inferred from it. Indeed nearly all the curves for rotifers are very similar in nature and I have not observed any relationship between the abundance of this rotifer and the seasonal series of algal pulses in the lakes I am familiar with. In the spring and early summer it is generally the case that the main development of zooplankton follows after that of the phytoplankton. It could be that the latter feed on the bacteria and protozoa which develop at the expense of the dying algal population or even that they benefit by their extracellular products.

When we consider the smaller algae, the minute nannoplankton or μ algae, then we are dealing with a range of size which all these animals can ingest and, in the laboratory at least, many of them have been seen to do this. Yet the position in nature is uncertain. Great difficulties assail the investigator in this field. It is a major task to determine the abundance of these animals because they can swim so fast that they are able to overcome more or less completely the randomizing effects of turbulence. An obvious example is the diurnal migration of planktonic crustacea. But they are not only distributed in a non-random manner in depth, with the type of dispersal varying over short periods of time, they are also distributed irregularly in a horizontal direction. The next problem is to recognise these algae in the guts of the animals. This is both difficult and tedious. Difficult because many of them are so altered by digestion that some new techniques are needed to recognise their remains. Tedious because the gut contents cannot be studied properly unless they are extruded, so that the examination of a few takes a considerable time. Yet to obtain satisfactory evidence we need to examine a large number. Lastly there is evidence that some algae resist digestion and so are excreted alive (references in Lund & Talling, 1957 p. 523). Thus the effect of grazing may even increase the preponderance of some of the algae which are ingested. All then that we can say at present is that, so far as freshwater algae are concerned, Munk and Riley may well be right in thinking that large size confers relative immunity from grazing.

If I have seemed to emphasize the difficulties of applying the theories of Munk and Riley I would use some of their own words (Munk & Riley, 1952 p. 232).."In short the analysis has revealed a situation too complicated to be tested easily by experiments or to be solved indisputably by theory". A paper of this sort is immensely stimulating even if one is as ignorant of mathematics as I am.

It may seem that I have chosen a very narrow theme for a presidential address and it is the case that I have discussed problems without producing solutions. It has illustrated how quite obvious questions remained unanswered for the lack of basic data. Nevertheless the discussion of so limited and perhaps at first sight uninteresting topic as flotation has I hope proved of some interest. It has I think shown that it is impossible to consider any ecological factor without discussion of most of the others. In this context we can see how valuable it is to have a Phycological Society, for this insures that those interested in algae from diverse angles meet at relatively frequent intervals with a consequent fertilisation of ideas. This is obviously a reason for any scientific society; but nowadays there are so many that the formation of another ought not to be undertaken lightly. Yet it seems to me that this one small aspect of one side of phycology could be used as a text to show that those who proposed the formation of our Society were right. Here to-day are gathered people who can supply specialist knowledge in all the topics raised or inform one where or how it can be obtained. No gathering in any other British Society, except possibly the Challenger Society, would possess this knowledge.

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SEVENTH ANNUAL GENERAL MEETING: LONDON, 2nd-3rd JANUARY, 1959.

By permission of Professor D. Lewis, F.R.S., a meeting of the Phycological Society was held in the Department of Botany, **University College of London**, Gower Street, London, on Friday, 2nd January and the morning of Saturday, 3rd January 1959. Dr G.E. Fogg kindly acted as Local Secretary. About 60 people attended the meetings. 20 members were accommodated at Connaught Hall (University residence), Torrington Square, London.

The programme included: a **Presidential Address** from Dr J.W.G. Lund; two sessions devoted to a **Symposium on algal physiology, biochemistry, ecology and cultures**; two sessions of **Demonstrations** and the **Seventh Annual General Meeting.**

The meeting started at 10.35 a.m. on 2nd January, with Dr J.W.G. Lund in the chair. Professor D. Lewis welcomed the members of the Society to the Department. Dr Lund thanked Professor Lewis for permitting the Society to hold this second meeting at University College, and also Dr Fogg and his colleagues for making the local arrangements for the meeting at a busy time of year. The following papers were read (see authors' abstracts at end of this report):

1. Dr J.D.A. Miller (U.C.L.). 'An extracellular enzyme produced by *Monodus*'.
2. Miss M.N.E. Adams (U.C.L.). 'Studies on a euryhaline specis of *Monas*'.
3. Mr E.R.S. Talpasayi (U.C.L.). 'Phorphorus utilization by algae.'
4. Dr J.H. Belcher & Dr G.E. Fogg (U.C.L.). 'Pigments from the bottom deposits of Esthwaite.'

Each paper was followed by discussion in which many of those present participated.

In the afternoon, Dr Fogg acted as Chairman, and the President (Dr Lund) gave an Address on 'Buoyancy in relation to the ecology of freshwater phytoplankton' which is printed in the present Bulletin. The address was followed by a lively discussion. Dr Maud Godward proposed a vote of thanks to Dr Lund, not only for a most interesting and stimulating address, but also for all his pioneer work on freshwater algae, and his work on behalf of the Society during his term as President; the proposal was warmly carried.

The remainder of this session was spent looking at demonstrations. These included: 'Apparatus for the culture of algae' (Dr Fogg and his colleagues, including a continuous culture apparatus, and special all-purpose apparatus for small cultures); 'Freshwater Bangioideae' (Dr J.H. Belcher); 'The development of *Thorea ramosissima* Bory (Miss E.M.F. Swale). The demonstrations were followed by tea in the Botany Department, and the Annual General Meeting (see below).

During Friday evening a very enjoyable Phycological Society Dinner was held at University College, which was attended by about 40 people.

The last session of the Symposium was held on Saturday morning, January 3rd, with Dr Mary Parke in the chair. The following three papers were read:

5. Dr J.H. Evans (Royal Holloway College). 'The microstratification of algae in the litter and mud of pond margins; with some observations on the accumulation of fat by diatoms during exposure to drought.'
6. Dr J.F. Talling (Freshwater Biol. Assoc.). 'The depth distribution of algal photosynthesis in natural waters.'
7. Dr M.R. Droop (Millport). 'Nutrition of *Oxyrrhis marina*.'

Each paper was followed by discussion. Afterwards several members showed some colour transparencies taken during the meeting at Galway in August 1958. The demonstrations were again available for inspection.

MINUTES OF THE SEVENTH ANNUAL GENERAL MEETING.

The Seventh Annual General Meeting was held at 4.30 p.m. on Friday, January 2nd. The President (Dr J.W.G. Lund) was in the chair, and 36 members were present.

1. **Letters from Members.** The Secretary reported that Dr A.J. Brook and Professor J. Feldmann had sent apologies for absence and good wishes for the success of the meeting.

2. **The Minutes of the Sixth Annual General Meeting,** held at Queen Mary College, London, on 2nd January 1958, had been circulated in Phycological Bulletin No. 6. The minutes were approved and the Chairman signed the official copy.

3. **Report from Council:**

   (A) **Report of Hon. Secretary.** The Secretary summarized the activities of the Society during the year 1958 as follows:

   (a) **Meetings:** during the year two general meetings were held - the meeting at Queen Mary College, London (the Sixth A.G.M.) on 2nd and 3rd January (see full report in Bulletin No. 6), and the Joint Meeting with the Third International Seaweed Symposium, held at Galway, Ireland, August 13th - 19th. The Galway meeting was attended by about 250 botanists, chemists, industrialists, and others interested in seaweeds; this number included 38 members of our Society. The meeting as a whole was a great success, thanks mainly to the hard work and the friendliness and hospitality of our Irish hosts, especially Dr Mairin de Valéra who looked after, in particular, the interests and the needs of the visiting phycologists. Reports of the Galway meeting will appear in Bulletin No. 7.

   (b) **The 1958 Council** met on 3 occasions: on 2nd January at Queen Mary College, London; on 14th August at Coláiste Einde, Galway; and on 2nd January 1959 at University College, London. Dr W.E. Jones has been appointed Hon. Assistant Secretary, with responsibility for organizing future Field Meetings of the Society.

   (c) **Subcommittees.** (i) **The Subcommittee for Marine Algal Check-list and Flora** has held two full meetings during 1958, and a further special meeting of those members responsible for work on the groups of larger algae. The schedule formulated in 1953 for the description of genera and species for the proposed Biological Flora of British Marine Algae has been revised, and the new schedule has recently been distributed to all members.

   A more complete glossary of terms to be used in the description of species belonging to the groups of larger algae is now available (free to members who apply to Dr Burrows); and a bibliography of literature relating to distributions of algae has been prepared by Dr P.S. Dixon and will shortly be ready for sale to members of the Society.

   It seems likely that the first genus and species descriptions for the Biological Flora will be published in 1959. This will be a big advance in that these will serve as patterns for future work. Reprints will be purchased by the Society for sale to members and others.

Work on the Flora of British Marine Algae is progressing. The subcommittee appeals again to members to make wider use of the algal record cards. Only 143 were sent in during 1958.

The work so far carried out in connexion with the Society's projects has already considerably advanced our knowledge of the distribution and biology of the algae on our coasts.

(ii) **The Subcommittee for Algal Nomenclature** has not met during 1958, but the Secretary, Mr Ross, reports that details of all the nomenclature proposals to be discussed at the next Botanical Congress (Montreal, 1959) are expected to be published very soon. He will consider the proposals carefully, especially those relating particularly to the algae, and if necessary will consult with other members of the Society.

(d) **Phycological Bulletin.** Dr E. Conway continues to be Editor, and Bulletin No. 6 (the largest no. so far) was produced in July 1958. 39 libraries now receive the Bulletin, which is very encouraging.

(e) The total membership of the Society continues to increase; there are now 112 members, compared with 106 a year ago. During the year 8 new members have joined the Society; they are Miss Irene M. Adams (Plymouth), Miss Kathleen M. Atkinson (Glasgow Univ. and Millport), Miss Joyce C. Hughes (Ferry House), Dr G.F. Leedale (Univ. of Durham), Mr J. Nizam (at Queen Mary College), Mr E.R.S. Talpasayi (at University College, London), Mr L.P. Turnbull (Bedford College), Miss Margaret Wraight (Univ. of Nottingham).

(f) Correspondence is in hand with the Chief Inspector of Taxes, Inland Revenue Dept., seeking recognition of the Phycological Society for the purpose of Section 16, Finance Act, 1958, whereby subscriptions paid to the Society will be allowable as a deduction from that part of members' incomes assessable to income tax under Schedule E. [More recently the Society has been recognised for this purpose.]

The Secretary's report was adopted, and the Chairman moved a vote of thanks to the Secretary for his work for the Society during the year.

(B) **Report of Hon. Treasurer.** The Treasurer presented the Income and Expenditure Account and the Balance Sheet for the year ended 6th November 1958 (see p. 83). Sale of Bulletins to libraries brought in the sum of £12. 2. 6. The surplus for the year was £28. 11. 7. It is intended to add a further £100 to the Deposit Account, although some of this money may be required during 1959 to support projects of the Subcommittee for Marine Algal Check-list and Flora. Dr Martin thanked the auditors (Professor W.T. Williams and Dr J.K. Spearing) for giving time to audit the accounts.

The Treasurer's report was adopted, and the Chairman moved a vote of thanks to Dr Martin and the auditors for the excellent way they looked after our financial affairs.

4. **Phycological Bulletin.** The Editor commented that the article listing chromosome numbers of the Phaeophyta in Bulletin No. 6 had met with wide approval, and it was hoped to extend the feature to other algal groups. It would be helpful to have suggestions from members of any other topics that it would be useful to have in the Bulletin. Line-drawings and diagrams can now be reproduced quite readily. It had been a pleasure to continue to receive copies of the News Bulletins of the Phycological Society of America, and three numbers were on the

table for perusal by members. Finally, Dr Conway again appealed to all members to support the Bulletin by sending in letters or short articles relating to any aspect of phycology.

Dr J.K. Spearing suggested that the number of libraries subscribing to the Bulletin might be increased if some complimentary copies were sent to libraries (especially in America) each year. It was agreed to keep this idea in mind.

5. **Field Meeting 1959, and future Field Meetings.** The Hon. Assistant Secretary reported that 27 replies had been received to the recently distributed questionnaire asking members' views on the subject of future Field Meetings. A good majority favoured holding such meetings annually (rather than biennially), and sufficient support was indicated for a field meeting in 1959 to justify arranging such a meeting. July and August were the most convenient months for a majority. Suggested localities to visit ranged from the Channel Islands to the Shetland Isles.

Dr Jones's report was adopted. In the discussion that followed, Mr Ross and Dr Godward suggested holding occasional meetings outside Britain (Roscoff and Banyuls were mentioned), perhaps in association with other Phycological Societies. Dr Barbara Douglas asked whether alternate marine and freshwater meetings would be a popular idea. Dr Peter Dixon proposed that for 1960 we try to arrange a joint meeting with the Société Phycologique de France in the Channel Islands, based at Peter Port on Guernsey; he knew the area, and it was likely that early September would be the best time to obtain suitable accommodation. Laboratory accommodation could be obtained at a school in Peter Port. The Chairman thanked members for the suggestions put forward, which would be borne in mind by the Council.

6. **Election of Auditors for 1959.** It was unanimously agreed that the present two auditors (Dr. J.K. Spearing and Professor W.T. Williams) be re-elected for 1959.

7. **Election of Officers and Members of Council for 1959.** The following Officers were unanimously elected to the 1959 Council: **President:** Dr Mary W. Parke; **Vice-Presidents:** Professor J. Feldmann, Dr M.B.E. Godward; **Hon. Secretary:** Mr H.T. Powell.

Only three nominations had been made for the three vacant offices of **Ordinary Member:** Dr E.M. Burrows, Dr G.E. Fogg, Dr Margaret Naylor: all three nominees were elected. All other members of Council were re-elected. (A complete list of members of Council and Subcommittees for 1959 is given p. (ii) of this Bulletin).

8. **Election of Professor Lily Newton, D.Sc., as an Honorary Member of the Society.** Dr Lund said that as our Constitution provided for the election of "persons who have rendered conspicuous service to the subject of phycology or to the Society" to Honorary Membership of the Society, Council wished to propose that Professor Lily Newton should be made an Honorary Member, as a mark of esteem for her great contributions to phycology and for her work on behalf of the Society. Professor Newton has been a distinguished member of our Council from the start of the Society, and was of course President for the two years 1955 and 1956. In this time she has done much to foster the development of the Society, which the Society now wishes to acknowledge.

The proposal was carried with warm acclamation.

H. T. POWELL, Hon. Secretary.

AUTHORS' ABSTRACTS OF PAPERS READ AT UNIVERSITY COLLEGE, LONDON, 2nd & 3rd JANUARY, 1959.

1. An Extracellular enzyme produced by *Monodus*. J.D.A. Miller.

Studies have been made on the nutrition of the freshwater alga *Monodus subterraneus*, a non-motile unicellular member of the Xanthophyceae (Miller & Fogg, 1957, 1958). The organism appears to be a strict phototroph, able to obtain carbon solely by the photosynthetic assimilation of carbon dioxide, although several organic substances serve as nitrogen sources in absence of inorganic nitrogen compounds. These are glutamine, succinamide, urea, uric acid and tryptophane. Investigations into the site and mode of breakdown of these organic substances have been initiated in the hope that light may be thrown on the nature of obligate phototrophy, and some preliminary results with a medium containing glutamine as sole nitrogen source are reported.

Monodus was grown in pure culture at 25°C. in Seitz filtered glutamine medium. The vessels were aerated with 1% carbon dioxide in air and continuously shaken. Paper partition chromatography of the medium after it had supported growth showed that the glutamine had been almost completely hydrolysed to glutamic acid. In order to determine whether the hydrolysis takes place inside or outside the cells, the following procedure was employed. Young, vigorously growing cells were centrifuged, suspended in sterile nitrogen-free medium and illuminated for a further 24 hours, after which they were found to have imparted to the nitrogen-free medium the property of hydrolysing glutamine. The nitrogen-starved cells themselves were able to break down glutamine to glutamic acid with great rapidity. Later it was shown that the cell-free supernatant of nitrate cultures also has glutamine-splitting activity. In all cases the activity is destroyed by boiling the supernatant for 15 minutes.

The above evidence suggests the liberation of an enzyme into the medium by the cells. Further evidence for this is provided by the specificity of the reaction: neither iso-glutamine nor asparagine is hydrolysed by the supernatant of *Monodus* cultures. It is not yet possible to state with certainty that the enzyme is liberated by healthy cells, although the use of exponentially growing cultures almost precludes the possibility of its liberation from dead cells.

This appears to be the first recorded case of the production of an extracellular glutaminase by a green plant.

References:

MILLER, J.D.A. & FOGG, G.E., 1957. Studies on the growth of Xanthophyceae in pure culture. I. The mineral nutrition of *Monodus subterraneus* Petersen. *Arch. Mikrobiol.*, 28, 1 - 17.

MILLER, J.D.A. & FOGG, G.E., 1958. Studies on the growth of Xanthophyceae in pure culture. II. The relations of *Monodus subterraneus* to organic substances. *Arch. Mikrobiol.*, 30, 1 - 16.

2. Studies on a euryhaline species of *Monas*. M.N.E. Adams.

Feeding currents, whereby a euryhaline species of *Monas* captures particulate matter, were described. The amount taken up by one flagellate was found to be dependent on the total volume of such particulate matter in the cell rather than its surface area.

Droop's medium E_6 with increased glucose concentration has been found to support growth of the flagellate together with a strain of the bacterium *Pseudomonas*, isolated from the same source. In this medium *Monas* divided once in just under six hours at 28°C. Additions to the basic medium of naturally occurring fluids such as blood, egg albumins, lemon juice and lettuce infusion, would not support growth of the flagellate alone.

Strains of the genus *Pseudomonas* were the only living organisms of the many different kinds tested which would support growth of *Monas*. In the presence of yeast and *Phaeodactylum* the growth of the flagellate was much slower than in control cultures.

Of the eighteen methods used to kill *Pseudomonas* before feeding to the flagellate, only that of ultra-sonic disintegration seems to have promise of yielding material containing the the essential nutrients for *Monas*.

Experiments were described in which the bacteria were treated with antimetabolites both during and before feeding to *Monas*. Two analogues of nicotinic acid were used - 3-acetyl pyridine and pyridine-3-sulphonic acid. It was shown that 3-acetyl pyridine was directly absorbed from the medium by the flagellate, creating a metabolic block. The bacteria were not affected. Pyridine-3-sulphonic acid, however, created a metabolic block in the bacteria, which in the absence of other nitrogen sources, was passed on to the flagellate.

3. Phosphorus utilization by algae.

E.R.S. Talpasayi.

Orthophosphate (dibasic or monobasic) is the form of phosphorus generally available to algae in nature and in cultures. It is not known whether organic phosphorus compounds (e.g. glycerophosphate, etc., which are often included in culture media) are taken in as such by algae.

Four species of algae belonging to diverse groups - *Anabaena cylindrica, Anacystis nidulans* (Myxophyceae), *Monodus subterraneus* (Chrysophyta, Xanthophyceae), *Chlorella vulgaris* (Chlorophyta) when tested *in vivo* showed the presence of strong acid-phosphatases (pH 5.8) which could split phosphorus-containing organic compounds to orthophosphate. These enzymes are presumably present on the surface of the cells. It is suggested that organic phosphorus compounds are broken down before the phosphorus is taken in by the cells. It has been found that, in all the algae tested, molybdenum in a concentration of 4×10^{-4} M (as sodium molybdate) strongly inhibits the activity of the enzyme.

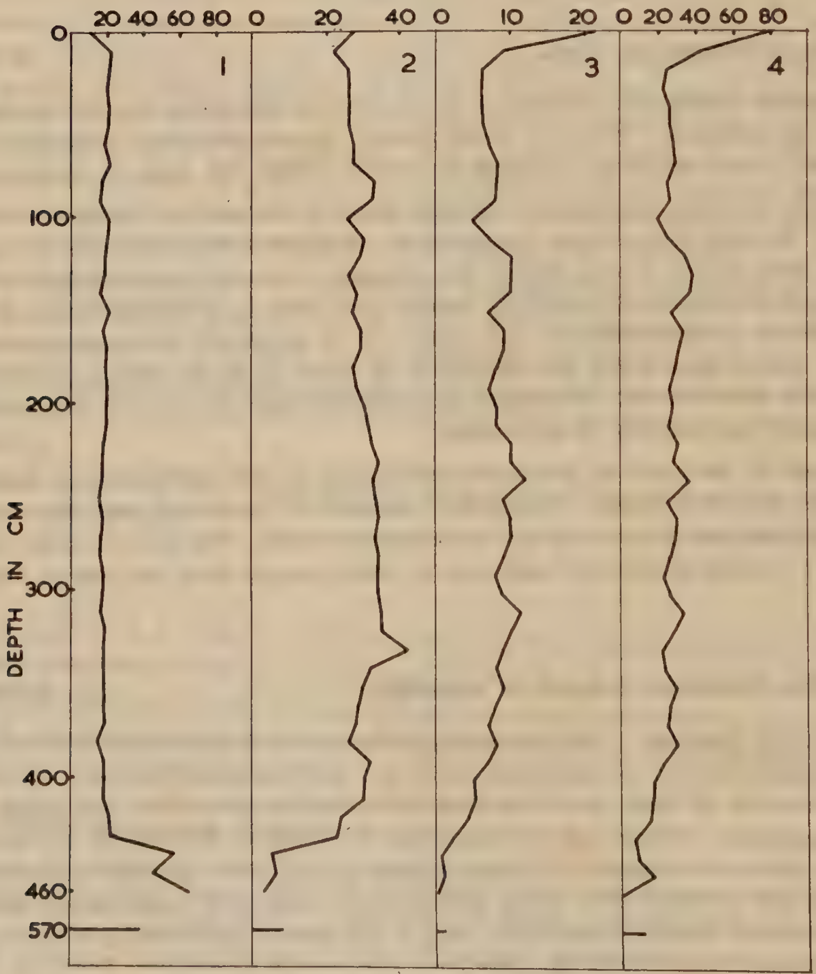
As a prelude to the study of phosphorus metabolism of blue-green algae a detailed analysis of *Anabaena* has been undertaken. Considerable amounts of phosphorus have been found in the form of stored polyphosphates soluble in 10% trichloracetic acid. The role of light in the synthesis and turnover of various phosphorus compounds is being studied with the help of radioactive phosphorus

4. Pigments from the bottom deposits of Esthwaite.

J.H. Belcher & G.E. Fogg.

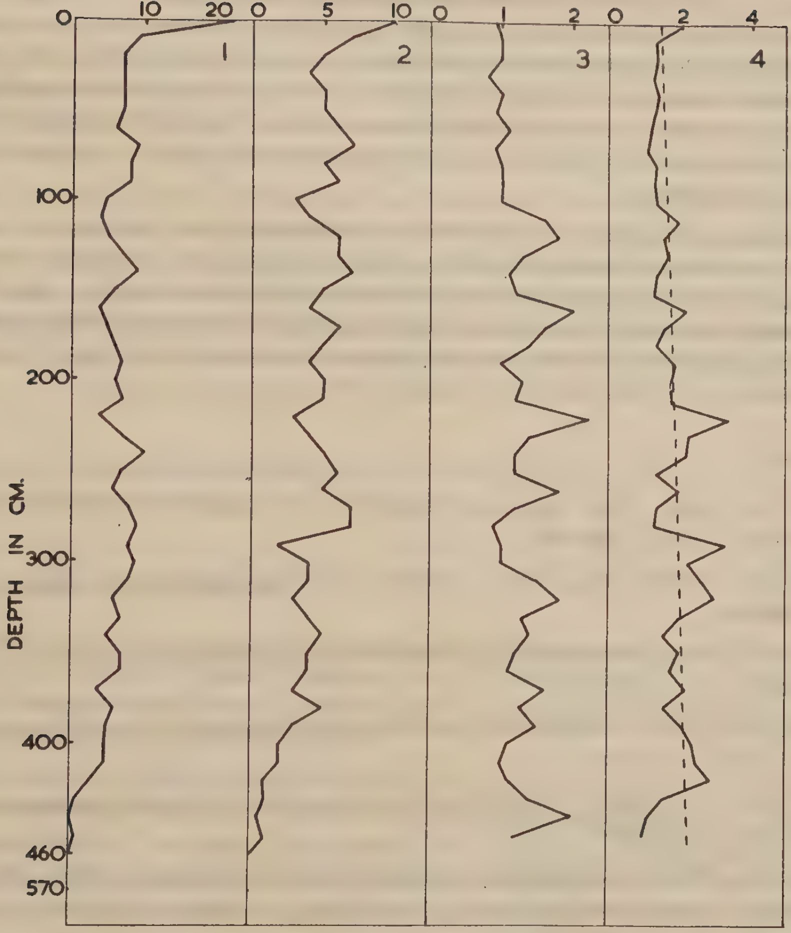
Acetone soluble pigments in the sediments of Esthwaite, English Lake District, have been separated and characterized chromatographically and spectrophotometrically. Chlorophyll degradation products similar to those described from North American lakes have been found to predominate but *a* - and *B*-carotene, lutein, and two unidentified epiphasic carotenoids are also present. In an attempt to relate the amounts of these pigments at different depths to the ecological history of the lake and its catchment area total amounts of a) chlorophyll degradation products, b) epiphasic carotenoids (mainly *B*-carotene), and c) hypophasic carotenoid (lutein), have been determined in samples taken at 10 cm. intervals from a core of sediment reaching down into the glacial clays. On the whole, the amounts of these three types of pigment parallel the amount of organic matter at different depths in the sediment (fig. 1) and thus are related to biological productivity in the past. Extremely small amounts are present in the clay (570 cm.) but there is an increase at the base of the brown mud (460 to 320 cm.) and amounts remain roughly constant until a rise occurs in the surface ooze (20 to 0 cm.). Certain minor fluctuations appear to be significant and become more evident when ratios are considered (fig. 2). The ratio of chlorophyll degradation products to epiphasic carotenoids remains nearly constant down to 100 cm., indicating that no appreciable decomposition of these pigments has occurred since the sediments were laid down, and below this fluctuates in a rather regular manner with peaks at about 50 cm. intervals. The ratio of chlorophyll degradation products to hypophasic carotenoid varies in a similar manner except for a general trend indicating the slow decomposition of lutein. These results suggest the existence of regular cyclic ecological changes from the Boreal period onwards which were interrupted at about 1000 A.D. by forest clearance.

Figure 1.



I, PERCENTAGE DRY MATTER; 2, PERCENTAGE LOSS ON IGNITION; 3, CHLOROPHYLL UNITS PER GM. DRY WEIGHT; 4, CHLOROPHYLL UNITS PER GM. LOSS ON IGNITION.

Figure 2.



1, EPIPHASIC CAROTENOIDS PER GM. DRY WEIGHT; 2, HYPOPHASIC CAROTENOIDS PER GM. DRY WEIGHT; 3, CHLOROPHYLL: EPIPHASE RATIO; 4, CHLOROPHYLL: HYPOPHASE RATIO.

5. The microstratification of algae in the litter and mud of pond margins; with some observations on the accumulation of fat by diatoms during exposure to drought.

J.H. Evans.

An alga stranded at the margin of a pond during a drought may avoid the consequences of exposure if it is below the surface of the litter or mud. To investigate the problem of a possible vertical movement, two methods were used. The first method was based on a slide technique used in mycological studies (Cholodny, 1930; Rossi, *et al.*, 1936). Pairs of slides were buried horizontally at depths of 0.5, 1, 2, 3, 4 and 5 cm. on the marginal litter and mud and left for two weeks. After collection, one of each pair was examined and the other placed in soil solution culture. In agreement with Petersen (1935) and

Tchan (1953), there was found to be a decrease in algal species with increasing depth. It was found also that there was a descent of viable cells of certain species (e.g., *Pinnularia viridis)* during the year as the water level dropped. In the second method, fragments of dead leaves from an exposed pond bottom were sampled for algae. The results suggested that there was a vertical movement, through a few millimetres, of the cells of motile algae according to weather conditions. This conclusion was supported by a statistical treatment of the results (Evans, 1959). Cells which descend below the surface, even if the movement is merely a passive one, are more likely to survive a drought than cells at the surface.

Fat accumulation was investigated by a simple measuring technique. In all the species observed (including *Pinnularia viridis, Nitzschia palea, N. frustulum,* and *Navicula pelliculosa*) there appeared to be an increase in fat during drying. That fat accumulation might result from water shortage has been mentioned by Collyer & Fogg (1955). Results of biochemical analyses indicate that the simpler technique can be used, with certain reservations, even with such small forms as *Navicula pelliculosa.*

References:

CHOLODNY, N., 1930. Über eine neue Methode zur Untersuchung der Bodenmikroflora. *Arch. Mikrobiol.,* **1**, 4, 620-52.

COLLYER, D.M. & FOGG, G.E., 1955. Studies on fat accumulation by algae. *J. Expt. Bot.* **6**, 256-275.

EVANS, J.H., 1959. The survival of freshwater algae during dry periods. *J. Ecol.* **47**, 55-81.

PETERSEN, J.B., 1935. Studies on the biology and taxonomy of soil Algae. *Dansk. bot. Ark.,* **8**, No.9, 1-180.

ROSSI, G. *et. al.,* 1936. Direct microscopic and bacteriological examination of the soil. *Soil Sci.,* **41**, 53-66.

TCHAN, Y.T., 1953. Relationships between the redox potential, penetration of light and vertical distribution of algae in sandy soil. *Australian conference on soil science, Summaries,* Vol.1, June 1953.

6. The depth distribution of algal photosynthesis in natural waters.

J.F. Talling.

The variation of algal photosynthesis with depth is of importance for the ecology of all equatic algae, whether attached or planktonic, marine or freshwater. The results discussed here are derived from experiments with planktonic algae, especially diatoms, but the basic relationships involved have a wider application. The general form of a photosynthesis-depth profile is determined by the relations between photosynthetic rate and light intensity and between light intensity and depth. Additional and more variable influence may follow from the existence of vertical gradients of temperature and differentiation between the photosynthetic characteristics of algal material present in the various depth strata.

Much work on the quantative determination of photosynthesis-depth profiles has involved the exposure of uniform plant material in glass vessels at various depths, accompanied by attempts to measure the vertical gradient of light intensity. Some early and particularly interesting work by Regnard at Monaco was shown, based on his book (1891).

Profiles drawn from the author's own work, with natural and cultured populations of planktonic algae, indicate the variations induced by a wide range of environmental factors. Vertical displacements of the profiles may follow changes both in surface illumination and in temperature. The variation in the depth of the photosynthetic zone, in waters with differing light transmission, is very great. In the examples shown it ranged from about 1.5m. in the White Nile to 60m. in the Pacific Ocean. In these examples, the high algal densities in the waters with low light transmissions enabled a large total photosynthetic productivity to proceed, despite the shallow productive layers.

Experiments in two lakes in the English Lake District, Windermere and Blelham Tarn, have shown several types of vertical differentiation of cells (affecting photosynthesis-depth profiles) to develop in the large spring populations of the plankton diatom *Asterionella formosa*. The depth-variation of photosynthesis in these populations partly reflects vertical differences in population density and partly certain divergencies in the photosynthetic rate - light intensity characteristics of cells in different depth strata.

Reference:

REGNARD, P., 1891. Recherches expérimentales sur les conditions physiques de le vie dans les eaux. Paris. vii + 500 pp.

7. **Nutrition of *Oxyrrhis marina* Dujardin.** **M.R. Droop.**

The colourless phagotrophic dinoflagellate *Oxyrrhis marina* can be cultivated indefinitely in the absence of other organisms of all kinds provided it is supplied with certain, as yet unidentified, lipids of vegetable orgin, such as those extracted by carbon tetrachloride from the rind of lemons.

The culture medium at first contained natural sea water, soil and liver extracts, etc. But these ingredients were gradually replaced by progressively simpler ones - e.g. liver extract, by casein digest, by casein hydrolysate and B vitamins, by amino-acids, fatty acids, sugars and B vitamins - all the time checking that growth of the flagellate remained undiminished over a number of subcultures in the simpler media.

The first successful medium in which all components (saving the lipids) were defined was a half strength artificial seawater buffered with glycylglycine with trade metals chelated with histidine and citrate. In addition the medium contained phosphate, nitrate, 14 B vitamins, 23 organic nitrogen and 24 carbon compounds in great dilution.

Simplification of this medium and identification of its essential components and bringing them up to adequate concentration was in the main a straightforward though lengthy undertaking. It was achieved by blockwise, then individual, omission of components, checking at each step over a number of subcultures that growth remained undiminished in the depleted medium. When only essential components remained, their most suitable concentrations were found by dose/response experiments for each of the compounds in question.

Acetic acid or ethanol (not any carbohydrate or carbon of amino-acids) proved to serve as carbon source, and alanine, proline, or especially valine (not nitrate, ammonium, or urea or other amino-acid) as nitrogen source. Water-soluble vitamin requirements proved to be limited to the thiazole half of the thiamine molecule, vitamin B_{12} (with a specificity pattern resembling that of *Ochromonas)* and biotin.

Although the mode of nutrition of *Oxyrrhis* is superfinially animal-like the pattern of nutritional requirements and abilities (in the absence of phagotrophy) is more typical of other lower algae than of Protozoa.

A full account of this investigation is to be published in *J. Mar. Biol. Ass. U.K.*, October 1959.

THIRD INTERNATIONAL SEAWEED SYMPOSIUM *
GALWAY, IRELAND. AUGUST, 1958.

The Third International Seaweed Symposium was held from August 13th to 19th 1958 at Galway, Ireland. The long established local seaweed industry, the variety of species on the shores, and the surrounding mountain scenery made this a very suitable and pleasant place to hold such a meeting. Over two hundred botanists, chemists and industrialists from all over the world attended. The proceedings were held at University College, by kind permission of the President and Governing Body, and were divided into three sections, Botany, Chemistry and Utilisation; and for part of the time, sessions of all three ran concurrently. During the week several field excursions were held as half-day or full day meetings, and one day was devoted to a symposium on intertidal ecology arranged as a joint meeting with the British Phycological Society.

By kind permission of the Bishop of Galway and the Department of Education, Coláiste Einde provided hostel facilities for many members while others stayed in local hotels.

The following short reports on various parts of the Meeting have been contributed by members.

Programme:

Tuesday, August 12th The members who arrived in Dublin were met in the morning by two coaches which took them to Galway via a peat factory. They were shown how sections of land are drained and the dry peat removed from the surface and transported to the Ferbane power station. They were taken round some of the workings in peat trucks on the factory railway.

In the evening a reception was given by the Galway Conference Committee at the Warwick Hotel. The Mayor of Galway made a speech of welcome, to which Dr F.N. Woodward replied on behalf of the visitors.

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* See also Dewar and Richardson, (1958), Nature, 182, 1781.

Wednesday, August 13th The Symposium was officially opened in the morning by Mr Sean Lemass, Minister for Industry and Commerce. Other speakers included the President of the College, Rt. Rev. Mgr. P. de Brun, and Dr T. Dillon, Chairman of the Organising Committee. The opening address was given by Professor R.D. Preston (Leeds) on "Biochemical and Biophysical Aspect of Some Seaweeds". Papers in the three sections, Botany, Chemistry and Utilisation, then occupied the proceedings until August 16th. Later on the 13th, members spent a very pleasant evening as the guests of the Minister, Mr Lemass, at a reception held at Colàiste Einde. Amongst those present were the President of the College, members of the staff and organising committee and the Mayor of Galway.

Thursday, August 14th In the evening Dr L.A. Walford (Washington) gave a lecture on "The Sea as a Potential Source of Food". In duscussing marine productivity, Dr Walford pointed out that the chemistry of sea water and dynamics or production of marine plants and animals indicate poverty rather than richness. However, the extent of the oceans is such that the resources are nevertheless vast. He advicated a more imaginative development of sea fisheries and cited particularly the value of fertilization experiments for increasing productivity.

Friday, August 15th As the day's session was devoted to the Chemistry Section, a shore collecting expedition was arranged in the morning for the botanists along the moderately exposed coast between Salthill and Mutton Island on the outskirts of Galway. Members spent an interesting morning in spite of the dull showery weather. During the afternoon facilities were available in the Botany Department of the College for sorting and examining material.

In the evening the excellent sectional dinners concluded with the speciality known as Irish Coffee served in lovely Waterford glass goblets which were later presented to each member, a very pleasant reminder of a happy occasion. After expressions of appreciation to the hosts on their extremely good arrangements, an all too short programme of traditional Irish song and harp music, followed later by dancing for everybody, ended the day.

During the first four days of the Symposium members had an opportunity of seeing the trade and historical exhibitions held in the College. The utilisation of seaweeds in commerce was the theme of the former, firms from Britain, France and Ireland contributing, while the latter illustrated the use made of seaweeds in Ireland in the past. Of particular interest were the photographs showing the making of land on the almost soil-less Aran Islands by the method of placing alternative layers of sand, seaweeds and manure on the bare rock. There were also pictures of the seaweed rafts or cleiḿíni used for transporting large quantities of weed ashore, a system still in use in the Clarenbridge area of Co. Galway. Films dealing with utilisation were also shown.

Saturday, August 16th Some of the members went on a tour of the seaweed factories of Arramara Teo., Kilkeerin and Atlantic Alginates Ltd., Ballyconneely, Co. Galway.

Others went by coach to two shores at Carraroe, Co. Galway. The first was a very sheltered gently sloping short at Garryroe where the predominant feature was the yellow colouration of almost all of the algae. The second consisted of the Dooleen beaches with reefs and *Lithothamnion* sands and a wide variety of algae. The day was bright and sunny, the water clear and warm and both littoral and sublittoral collecting highly favoured. Sorting facilities were available at a school nearby (here the walls were dressed with *Lithothamnion* sand) where a quite exceptional tea was provided.

Sunday, August 17th Some members went to the Aran Islands on board the Noamh Eanna. The sea was flat calm and the sun made an occasional appearance. The ship called at Inisheer, Inishmaan where the local inhabitants, dressed in home-woven clothing, rowed out to her in their canvas and wood craft, or "currachs". At Kilronan on Inishmore the Naomh Eanna tied up to the pier and the passengers had a few hours ashore. Many took "jaunting cars", each drawn by a willing horse, to Kilmurvey, where limestone pavement was much in evidence and a prehistoric fort, Dun Aengus, overlooks the sea above precipitous and undercut cliffs.

The alternative excursion was a trip to Spanish Point, near Miltown Malbay, Co. Clare, where W.H. Harvey did much of his collecting. The route was coastal for part of the way and members had a chance of seeing the famous Burren district of Co. Clare with its bare limestone terraces and rich calcicole flora hidden in the rock crevices. The day was fine and warm and the party spent an interesting time at the Point exploring this exposed shore with its extensive rock ledges and deep pools, a contract to the shores seen at Carraroe. At Lahinch, where a break was made for tea, the party saw "dillisk" (*Rhodymenia palmata*) beihg sold in the streets for chewing. On the return journey a stop was made to view the cliffs of Moher, which rise from the sea in a vertical wall to well over 600 ft., an impressive sight.

Monday, August 18th A Symposium on Intertidal Ecology was held in collaboration with the British Phycological Society. Later in the day, Dr Woodward presided over the final business session of this Third International Seaweed Symposium which concluded with the decision that the 1961 meeting should be held in Paris.

Tuesday, August 19th The members still remaining went by coach through the mountains and by the lakes of N. Galway and S. Mayo, to Westport. There was a stop for lunch and shore collecting at Roonah Quay, near Louisburgh. On the return journey tea was provided at hotels in the trout fishing country. The weather was less favourable than at the weekend but the magnificant scenery was very much in evidence.

The meeting as a whole proved to have been highly successful and stimulating. That it was so well organised must be attributed to the work of the Organising Committee under the chairmanship of Dr T. Dillon, and the unceasing attention of the secretaries, Dr C. Ó hEocha and Dr M. de Valera. The fact that Coláiste Einde was made available as a hostel resulted in many of the members seeing much more of each other than would have been otherwise possible, in a very congenial atmosphere created by Dr de Valera and the staff.

J.M. Kain
H. Parkes

Chemical Sessions

The Scientific part of the Meeting was opened by Professor R.D. Preston (Leeds) who gave a fascinating account of the carbohydrate constituents and structure, as determined by the electron-microscope and X-ray measurements, of the cell wall of a wide variety of seaweeds. From this study three main groups emerged. Group 1, which includes the green seaweeds, *Cladophora*, *Chaetomorpha* and *Valonia*, but not *Spongomorpha*, has parallel microfibrils, arranged in two directions at right angles, and has an X-ray diagram indistinguishable from Cellulose I. Group 2, to which all the *Rhodophyceae*, so far examined, and many of the *Chlorophyceae* belong, contains thinner randomly arranged microfibrils and a high proportion of amorphous material. Finally, Group 3 which consists of a heterogeneous collection of some species of *Cladophorates* and some *Siphonates* containing an, as yet unidentified, highly crystalline material oriented in a manner similar to that of higher plants. Complementary to this paper was a comprehensive review, by Professor E.L. Hirst, (Edinburgh) of the fine structure, in so far as it is known, of the many and varied polysaccharides found in the brown, red and green algae. Three recent achievements might be mentioned: the proof by Araki, from partial acid and enzymic hydrolysis, that agarose consists of repeating units of 4-β-D-galactosyl-3:6-anhydro-L-galactose, the anhydro-sugar being glycosidically linked in the chain to C_3 of galactose; the recent work in Bangor and Edinburgh which whas established the presence of mannitol at the reducing ends of 50% of the 1:3-linked glucose chains, and finally the work of Fischer and Dorfel which has revealed the presence of a second uronic acid, L-guluronic acid, in the polymeric alginic acid.

Various aspects of alginic acid were dealt with by other speakers. Dr H.M. Ulrich (Austria) critically examined the fine structure of alginic acid, as advanced by various investigators, and discussed some of the industrial uses of alginate in the light of its structure. The precipitation of sodium alginate solution by different metallic ions was described by Mr R.H. McDowell (London). The variation in viscosity of alginate isolated from different sources and by different methods was recorded by Mr A. Haug (Norway) and a new method of potentiometric titration of alginic acid was introduced by Mr M.F. Van der Lande (France). The double refringent gels, produced by slight changs of pH in mixture of anionic colloids such as alginate or carragheen and colloid cations like polyglucosamine, have both components in a fixed orientation. The authors of this paper, L. Langmaack and H. Theile (Germany), consider that the formation of ordered structure *in vivo* may be due to this mechanism.

A difficulty in dealing with the sulphated polysaccharides of the red and green algae lies in the separation of a single polysaccharide. Most of the known methods of fractionation have proved unavailing with the more complex extracts. The use of the detergent, cetyltrimethylammonium bromide, which has proved of value in separating mucopolysaccharides, has given some success, and Dr J.R. Turvey (Wales) gave details of extensive fractionation experiments with this reagent and other routine methods on the water-soluble polysaccharides of *Porphyra umbilicalis*. Furthermore, the presence of sulphate residues makes these polymers very intractable and another major problem facing the investigator is the removal of these groups without destruction of the polymer. Chemical and enzymic methods tried by various workers have been re-explored at Bangor. Evidence of sulphate removal by the enzymes of *Patella vulgata* was provided by Dr. P.F. Lloyd (Wales), although no information on the extent of degradation of the residual polysaccharide was recorded.

Various structural investigations of polysaccharides from red seaweeds were described. Two similar water-soluble extracts, one from *Laurencia pinnatafida* and the other from *Furcellaria fastigiata* have been investigated by Professor P. O'Colla (Galway). Both are sulphated, and contain a backbone of 1:3-linked galactose units, together with xylose and uronic acid residues. The galactan sulphate from *Porphyra umbilicalis* (J.R. Turvey) reveals similarities with material from *Porphyra capensis* in that it too contains 6-O-methyl- and 3:6-anhydro-D-galactose. Recent work by C. Araki, S. Hirase and R. Ito (Japan) shows the essential similarity of the water-soluble polysaccharide "Funori", extracted from *Gloiopeltis furcata*, to age; 55% of agarobiose being separated after partial methanolysis. The main difference appears to be the considerably higher sulphate content (18.5%) of "Funori". Dr E. Percival (Edinburgh) discussed the resemblance between the water-soluble polymers from the three green seaweeds, *Acrosiphonia centralis (Spongomorpha arcta)*, *Ulva lactuca*, and *Enteromorpha sp.* Glucose, xylose, rhamnose, uronic acid and sulphate groups are common to all three extracts. Structural investigations also revealed similar types of linkage. The difference of the extract from the morphologically similar seaweed, *Cladophora rupestris*, was emphasised. 4-O-D-Glucuronosyl-L-rhamnose units, characterised for the first time, were shown to occur as end groups in the *A. centralis* polysaccharide. The attention of chemists was drawn by Professor H. A. von Stosch (Germany) to the apparent identity of leucosin extracted from diatoms and laminarin found in the phaeophyta.

Three low molecular weight compounds, a glycose, O-α-D-galactopyranosyl 1-1-D-glyceritol, from two members of the Florideae, and two new internal salts, 2-L-amino-3-hydroxy-1-propanesulphonic acid and N-(D-2:3-dihydroxy-*n*-propyl)-taurine from *Polysiphonia fastigiata* and *Gigartina leptorhynchos* respectively, have been isolated by Mr B. Wickberg (Sweden).

The possible use of a novel method of determining the type of linkage present in carbohydrates was suggested from preliminary experiments, by Mr Finan (Glasgow), with the mass spectrometer.

The danger of prolonged storage of dried seaweeds was illustrated by Dr E.G. Young (Canada), who recorded the marked degradation, as determined by intrinsic viscosity and gel strength, of carrageenin extracted from dried *Chondrus crispus* which had been stored at 4°, 10° and 20° for two years.

On the clinical side Dr C.C. Burt (Edinburgh) described investigations on the use of laminarin sulphate as a blood anticoagulent. The toxic effects produced in both rabbits and dogs by daily doses for one or two weeks were ascribed to lack of binding of laminarin sulphate to the plasma proteins. The anti-cancerous properties of a complex phycocolloid material extracted from seaweeds and marketed under the name of algasol-T-331 was described by Professor G. Rossitto (Italy).

Several papers were devoted to non-carbohydrate products synthesised by seaweeds. Fluorescent materials present in various species of the Rhodomelaceae were examined by Mr C. Ó hEocha (Galway); the absorption characteristics were determined and in one case crystalline material was separated and partially characterised as an aromatic acid conjugated to a single double bond. The water-soluble chromoproteins, phycoerythrin and phycocyanin, isolated from *Porphyra tenera* at the Institute for Protein Research, Kobe, Japan by Professor T. Fujiwara (Japan) contain seventeen of the common amino acids and some work has been done on the peptides isolated after enzymic hydrolysis of phycoerythrin. Work in Canada, reported by Dr E. G. Young, revealed the presence of many of the common amino acids and some simple peptides in *Chondrus crispus*. Complete extraction of the protein proved very difficult, but the distribution of amino acids in the insoluble protein was similar to other algal proteins. The brown colour produced in alkaline seaweed extracts was attributed by Mr A. Haug to the presence of fucosan, a phenolic reducing substance. The variation in quantity of this and of niacin in brown algae with changes in conditions of growth and age was discussed by Mr B. Larsen (Norway).

E. Percival.

Botanical Sessions.

Three botanical sessions were held and some 20 papers were read covering many aspects of algal biology.

Three papers were concerned with taxonomic problems: H. T. Powell (Scotland), on speciation in *Fucus*, proposed to accord specific rank only to five of the fifteen currently recognised species; P.S. Dixon (England) concluded that much of the confusion surrounding *Pterocladia pinnata* and related forms results from morphological variations due to interaction of season and environment; M. Naylor (England) showed that the four British species of *Cystoseira* could be differentiated by the structure of their resting nuclei.

T. Segi (Japan) gave a spirited account of the *Monostroma* industry in Japan and of the life history of the alga, illustrating his talk with unusually artistic transparencies. B. Grenager (Norway) discussed the possibility of predicting algal distribution in unknown areas entirely from the inspection of charts.

Papers of chemical interest were read by E. Baardseth (Norway) and H.A. Von Stosch(Germany): the former on the occurrence and estimation of physodes in brown algae, which prove to vary in volume with salinity and coreallate with the amount of reducing phenols in the tissues; the latter on leucosin of diatoms and chrysomonads, which, normally in vacuolar solution, could be precipitated amorphously by alcohol or acetone or in crystalline form by diacetin.

Physiological studies in *Fucus vesiculosis* were the subject of three papers: J.A. Chambers and J.H. Burnett (Scotland) on the effects of respiratory inhibitors on endogenous respiration of discs from vegetative tips, which prove to resemble effects produced in higher plants, thus implicating a heavy metal oxidase. An ingenious apparatus for the continuous electrical recording of oxygen tension was described by J. Kanwisher (U.S.A.), which utilizes the permeability characteristics of thin sheets of polythene. The method was used to measure the respiratory and photosynthetic capacities of several intertidal species. W.R. Müller-Stool (East Germany) read a paper on the variation in morphology and chemical composition of *Fucus vesiculosis* in the Baltic with environmental conditions.

W.P. Jacobs (U.S.A.), on regeneration in *Caulerpa*, emphasized the main features, as regeneration of the whole plant from small pieces, assisted by a ready production of cross walls when stimulated, coupled with the coenocytic habit, and maintenance of polarity of the original tissue. Observations on growth of transplanted giant kelps were described by F.T. Haxo and M. Neushal (U.S.A.): successful transplants were as vigorous as the controls but many facturs interfered with successful establishment.

The remaining papers were concerned with algal cultures: G.E. Fogg (England), on the possibility of mass cultures of marine mucro-algae as a source of food-stuffs, said that no strain has been found which possesses all the necessary attributes for economic utilization. As an approach to the problem of nitrogen fixation in the sea, M.B. Allen (U.S.A.) described the behaviour of some freshwater nitrogen-fixing Cyanophyceae when adapted to high salt concentrations. L. Provasoli (U.S.A.) showed how far proper morphological development of *Ulva lactuca* in bacteria-free culture there are needed certain conventional plant hormones such as gibberellin in combination with kinetin and adenine. G. Boalch (England) described the morphological variations produced in bacteria-free cultures of *Ectocarpus confervoides*, the relative predominance of prostrate and erect systems being altered by such factors as salinity, agitation, temperature or illumination. M. Droop (Scotland) discussed the probable role of vitamin B_{12} in phytoplankton ecology.

M. Droop.

Symposium on Intertidal Ecology.

A one-day Symposium on Intertidal Ecology was held at University College, Galway on August 19th., 1958 under the Chairmanship of Dr M. De Valera and Dr J. Koster, Despite its title, the symposium covered both intertidal and sublittoral ecology. Following, as it did, immediately on the 3rd. International Seaweed Symposium, in which interest centred on economic as well as other aspects of Phycology, it was appropriate that some of the papers should deal with the ecology of algae of economic importance. Such papers dealt with methods of assessing abundance of crop plants in the field, Dr E. Baardseth (Norway), and with autecology studies of *Gigartinales*, Dr C.I. MacFarlane (Canada), and of *Macrocystis pyrifera*, Dr W.J. North (U.S.A.). The scope of the symposium was, however, much wider than this and illustrated clearly both the progress which has been made in this branch of Phycology in recent years and also the greater breadth of approach now applied to its study. Both of these features were stressed by Professor T.A. Stephenson (Aberystwyth) who introduced the symposium. In a review paper, he emphasised the important contributions made, on the one hand, by an application of new methods to the study of marine ecology and, on the other, by a synthesis of knowledge gained over long periods of time and over wide areas: he also stressed the importance of appreciating the interactions of both plants and animals in a marine environment. Evidence for the dynamic nature of marine ecological systems was put forward by Dr E.M. Burrows (Liverpool) who pleaded for a greater use of experimental method, alongside descriptive techniques, in trying to find the causes of the distributions of algae.

The value of a combination of field observations and laboratory culture methods applied to autecological studies of marine algae was shown by Mr G. Russell (St. Andrews) in his study of *Pylaiella littoralis* (L.). Work of this kind will help considerably in solving many of the taxonomic problems facing algal ecologists. This point was again underlined by Dr P.S. Dixon (Liverpool) with reference to the *Floridae* and to *Ceramium* in particular.

The development of self-contained diving apparatus is likely to provide the means for considerable advances in knowledge of the sublittoral region for which, as yet, relatively little even purely descriptive work, has been carried out. The potential value of such apparatus was illustrated very clearly by Professor C. Skottsberg (Sweden) who followed progress in the study of sublittoral ecology in the Antarctic between 1902 and the present time. Descriptive work in the sublittoral region was also reported by Mr M.J. Ernst (France) and Dr J. Kain (Port Erin). It was difficult to avoid the impression that progress in the understanding of sublittoral ecological processes will be slow until self-contained diving apparatus can be used on a large scale by teams of workers. The immediate importance of such apparatus in carrying out experiments in the sublittoral region was, however, apparent from the work of Professor F.T. Haxo and Mr M. Neusull Jr. (U.S.A.) on the autecology of *Macrocystis pyrifera*.

A number of papers dealing with descriptive work in the intertidal region of the shore completed the programme of the symposium: Dr C. Bas (Spain) was concerned with *Laminaria rodrigettzii* on the Catalonian coast, Dr H. Blackler (St. Andrews) with problems of seasonal ecology, Dr E. Conway (Glasgow) with high level *Porphyra* associations on northern shores, and Dr A.D. de Virville (Franch) with the flora of "Chenaux a marées".

A symposium of this kind, bringing together marine ecologists from different parts of the world, would have seemed an admirable opportunity for a consideration of the possibility of co-ordinating ecological research on a basis wider than that of the individual worker. But, the extreme diversity of the problems occupying workers in different parts of the world at the present moment suggests that we are not yet in a position to get to grips with the essential problems of marine ecology. Perhaps the time is not yet ripe for a synthesis and planning of work, but this should be kept in mind for the future.

E.M. Burrows.

NOTES ON TWO IMPORTANT ALGAL HERBARIA

by **P.S. DIXON.**

Many of the present taxonomic difficulties in the algae result from the failure of phycologists to refer back at all times to original authentic material. In this connection, knowledge of the present location of the classical herbaria is of prime importance.

Several important catalogue of algal herbaria and their location have been published recently (Dickinson, 1952; Newton, 1952; Womersley, 1956; Koster, 1954; 1957; 1958) but there is still some confusion with certain collections where it is not apparent how much of the original herbarium has survived, or even where the surviving fragments, if any, are to be found. This situation is critical in that it is often the most important algal herbaria about which least is known.

During preliminary work towards the preparation of the volume on Rhodophyta for the Flora of British Marine Algae it became obvious that the existing information relating to several of the most important algal herbaria was very fragmentary and that many of the statements in the literature were contradictory. The lack of knowledge about these collections is such that recently several phycologists have proposed nomenclatural changes as a result of the examination of an isolated surviving specimen of a classical herbarium, without any investigation of the eligibility of that specimen for consideration as a nomenclatural type. No attempt has been made either to elucidate the history of the supposed 'type specimen' or to search for additional surviving specimens of the same entity. Such proposals will not clarify the present taxonomic chaos in the algae, but merely add to it.

Much of the confusion with regard to the classical herbaria is the outcome of what might be called the 'stamp-collector' attitude of many of the earlier botanists. A specimen on which a description had been based was discarded if a more luxuriant,or less imperfect specimen came to hand. As Stearn (1957) has indicated, eighteenth century botanists tended to regard as duplicates any specimens identified as belonging to the same species by the taxonomic standards of the time and rarely kept more than a few specimens to represent a species. Furhtermore, many botanists circulated their specimens among friends, either on loan, or as outright gifts. As a result of these practices, it must be realised that in all early herbaria **there is a definite possibility that the specimen now present is not the original specimen on which a species description was based, and that the specimen retained may not be conspecific, by modern taxonomic standards, with the original.** In the algae, where taxonomic criteria have changed considerably during the last 200 years, this situation is particularly critical. Definite proof of the survival of the original specimen can be obtained in two ways, from illustrations, where these exist, and from annotations on the specimen.

A second source of confusion is that many of the old herbaria have passed subsequently from one botanist to another. Even where the original collection has not been divided and distributed widely, as has often happened, it may have been incorporated into other collections by successive owners. If the original labels, (which are often sparse, consisting frequently of little more than the name of the species) have been retained, then it may be possible to determine the origin of the specimen from the handwriting, but the common habit of removing the labels of the previous possessor makes attribution impossible, or, at best, very difficult.

The present note contains summaries of information regarding the algal herbaria of William Hudson and John Lightfoot. Today, it is very probable that the history of these herbaria can never be elucidated fully, but it is thought that the information presented here, incomplete though it may be, will be of interest to other phycologists engaged in taxonomic and nomenclatural research.

WILLIAM HUDSON, (1730 - 1793)

Hudson was one of the first English botanists to adopt the Linnaean system of classification and nomenclature and the two editions of *Flora Anglica* (Hudson, 1762; 1778) are of considerable importance to phycologists in that both editions contain a large number of original descriptions of algae. Many of these descriptions are sufficiently vague to make the critical determination of Hudson's herbarium material of prime importance.

It has been assumed generally that Hudson's herbarium had been completely lost. There have been recent statements that a few specimens were still in existence, either at the British Museum (Natural History) or at the Herbarium of the Royal Botanic Gardens, Kew (Dickinson, 1952; Koster, 1957) but a widespread search of the national herbaria disclosed the existence of nearly two hundred algal specimens which had once belonged to Hudson, or which at some time had passed through his hands. An attempt has been made therefore, firstly, to prepare a catalogue of these specimens, and secondly, to elucidate their history and if possible their eligibility for consideration as nomenclatural types.

The persistent legend 'that the Hudson herbarium had been burnt' seems to have some factual basis. Smith (1811*), a personal friend of Hudson, states that during the winter of 1783 "his house and the greater part of his literary treasures were destroyed by a sudden fire". It is not known whether his herbarium, or a part of it, survived the fire; Smith makes no mention of its survival, but this would appear to be improbable, as Hudson's zoological collections were lost "the fire entirely destroyed a project .... of publishing a *Fauna Britannica* .... for which he had long been collecting materials". Goodenough and Woodward (1797, p. 234) comment that they had doubts as to the identity of some of the species described by Hudson and that "these doubts, in consequence of the loss of his herbarium, cannot now be cleared up". In this connection, it should be noted that of the Hudson specimens which have been located, a few have scorched margins, but there is nothing to indicate whether these are specimens which survived the fire of 1783, or whether the scorch marks are indications of a subsequent, unrecorded, conflagration.

Hudson possessed a herbarium after 1783, because at his death in 1793 it was bequeathed to the Society of Apothecaries of London, to whom he had been Demonstrator of Plants at the Chelsea Botanic Garden from 1765 to 1771). That the herbarium was actually received is shown by the statements in the Memoirs of the Botanic Garden, which state "he bequeathed to the Society his dried specimens of plants which were delivered by Mr Bolton Hudson, his executor" (Field, 1820, p. 68; Semple, 1878, p. 93). The value placed on this collection by the Society is shown by the fact that in 1806 "the dried plants bequeathed to the Society by the late Mr William Hudson were presented to Mr Thomas Wheeler, Demonstrator" (Field, 1820, p. 96; Semple, 1878, p. 118). There is no further definite information about this collection, but is some evidence to suggest that the specimens passed eventually into the hands of A.B. Lambert. It is not known if this herbarium contained any algal specimens, but as will be seen it would appear that it did not.

As stated already, Goodenough and Woodward (1797) comment on the loss of the Hudson herbarium, but they state also (p. 118) that they had examined "the remains of Mr Hudson's collection, now in the possession of A. B. Lambert". The herbarium bequeathed to the Society of Apothecaries was still at the Chelsea Botanic Garden at the time that this statement was made and in view of the care taken by Goodenough and Woodward to examine authentic herbarium specimens it is surprising that they make no mention of this collection; one must assume that this omission is due simply to the absence of algae.

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* For the actual dates of publication of this, and other, parts of Rees's *Cyclopaedia* see Jackson (1896).

Don (1824) in his account of the Lambert Herbarium, comments about "all that part of the herbarium of the celebrated Mr Hudson, which contained his Cryptogamia; this was purchased by Mr Lambert, and formed an extensive collection of indigenous and exotic Lichens, Mosses, and Fuci, but unarranged .... " which is presumably the collection studied by Goodenough and Woodward. Originally, Lambert intended to bequeath his herbarium to Sir J. E. Smith, but as Smith died in 1828, Lambert's herbarium was sold by auction at his death in 1842. Fortunately, two copies of the sale-catalogue of this auction are in existance, in the Libraries of the British Museum (Natural History) and the Royal Botanic Gardens, Kew (Anon, 1842). These catalogues are of particular interest in that in both copies the purchasers of the various items sold are recorded in manuscript, together with the prices obtained. Of the items sold on the third day of the sale (July, 27th. 1842), item 259 is described as "Mr Lamberts own indigenous herbarium, including a portion of Hudson's herbarium, about 500 plants". This item, which was sold to William Pamplin, a botanical dealer and publisher, for £2 - 5s - 0d., is presumably the herbarium, or a part of the herbarium bequeathed by Hudson to the Society of Apothecaries and given by them to Wheeler. Wheeler did not die until 1847, but there is some evidence to suggest that Lambert acquired his collections, although definite proof is wanting. As Don (1824) does not make any mention of the Wheeler collection it must have been obtained after 1824. Item 260, described as "Dickson's Cryptogamous plants, which appears to have formed originally the cryptogamous portion of Hudson's herbarium, about 200 species", was bought also by Pamplin, for £2 - 13s - 0d. This is presumably the collection commented upon by Don and, earlier, by Goodenough and Woodward, but it has not been possible to elucidate the connection with Dickson. A knowledge of the details of the bequests of Hudson's will would be invaluable in this connection but no information has been obtained. The cryptogamic herbarium may have been given by Hudson to Dickson at some time before his death, thus being omitted from the Chelsea bequest, or it may have been bequeathed to Dickson.

Pamplin appears to have divided the algae between W. J. Hooker and Edward Forster. Hooker's portion is now incorporated, with the remainder of his herbarium, into the general herbarium at the Royal Botanic Gardens, Kew. Forster's herbarium was sold by auction at Messrs. Sotheby's on March 24th. 1849. The entire herbarium was bought by Robert Brown for the sum of £5 - 15s - 0d. Brown's herbarium was bequeathed by him to J. J. Bennett in 1858, whilst Bennett's collections were bequeathed to the British Museum in 1876 (Anon, 1876). It is possible that some Hudson specimens were transferred to Kew, and also the herbarium of the Royal Botanic Gardens, Edinburgh, in 1876, at the break-up of the Bennett collection. By Bennett's directions to his executrix (Anon, 1876), the British Museum was to have the first choice of specimens, the Kew herbarium the second choice and the Edinburgh herbarium, the third. It would appear though that the bulk of the Forster herbarium passed to the British Museum.

Of the Hudson algal specimens which had been in the possession of A. B. Lambert, the majority are now located in the herbarium of the British Museum with a label indicating their origin from the Forster collection. Unfortunately, the original (Hudson) labels have been removed from a number of these specimens, which have been remounted, presumably by Forster; the only indication of their origina is a label 'Hudson Sale' in Forster's hand. Of the remainder, at Kew, the majority appear to have been remounted by Lambert, but in most cases the original label, in Hudson's hand has been stuck on the sheet with the specimen. Ocassionally, a number of specimens are remounted with the original Hudson label and it is not clear whether this identification applied to all, or only to one, of the specimens.

Two Hudson specimens, which appear to have been in Lamert's possession have been located at the herbarium of the Royal Botanic Garden, Edinburgh, which received them through the herbarium of A. Menzies. It has not been possible to elucidate this transference; Menzies died in the same year as Lambert (viz. 1842) so that it must be assumed that these specimens were obtained before the death of the latter. It is possible that other Hudson specimens are located at Edinburgh, obtained in the same way or at the break-up of the Bennett collection in 1876, but it has not been possible to check the collection in detail.

In addition to the specimens already mentioned, there are about a dozen Hudson algal specimens at the British Museum, all clearly labelled in Hudson's hand, received through the Pulteney herbarium. Richard Pulteney died in 1801, and his collections were bequeathed to the Linnean Society (Gage, 1937). The Linnean Society disposed of a number of miscellaneous collections, including the Pulteney herbarium, in 1863. These miscellaneous collections were sold by auction by J. C. Stevens on 10th. November 1863. Lot 247, described as "the British herbarium of Dr Pulteney, consisting of 5 folio volumes and 12 parcels" was bought by the British Museum for £1 - 10s - 0d.

Moreover, there are a large number of other specimens in other herbaria, reputedly identified by Hudson. A few from the Hugh Davies collection, are located in the general herbarium at the British Museum. It is possible that others may occur in that portion of the Hugh Davies collection now in the National Museum of Wales, Cardiff, which received it through the collections of J. E. Griffith (Hyde, 1927).

Sir Thomas Frankland, a pupil of Hudson, received a large number of specimens from him, but these are now scattered. Twenty Frankland specimens, one of which bears an annotation 'given by Hudson', are now preserved in a folder at the Linnean Society, but the bulk of the Frankland collection would appear to be at the Royal Botanic Gardens, Kew. Frankland was an enthusiastic collector of algae, communicating specimens to most of his contemporaries. Those specimens received by Dawson Turner are in the general herbarium at Kew, whilst a large number of specimens given by Frankland to Lightfoot are still to be found in the Lightfoot herbarium. The Lightfoot specimens are of considerable importance in that a number bear annotations to the effect that they are "identified by Hudson himself"; the Dawson Turner specimens would appear to have been received after the death of Hudson, as none bear such remarks. It must be presumed that the large number of specimens identified by Hudson in the Frankland collections was responsible for the statement by Britten and Boulger (1931) that Frankland "has Hudson's marine plants". In view of the numbers of phycologists to whom Frankland communicated specimens, it is very probable that other portions of his herbarium exist elsewhere, the significance of which has been overlooked.

According to Geldart (1914), the herbarium of Hugh Rose, an apothecary of Norwich, contained a large number of specimens identified by Hudson, but on passing into the possession of J. E. Smith, the original labels were removed. The contents of this herbarium are not known but for various reasons it would appear improbable that it contained any algae.

There are thus about 200 algal specimens which once belonged to Hudson, or which at some time passed through his hands in existence at the present time. From the evidence of Smith and Goodenough it would appear that there is only a very slight chance that any parts of the herbarium on which the two editions of *Flora Anglica* were based survived the fire in 1783. Furthermore it must be stated that no correlation could be obtained between any of the surviving specimens and the original descriptions, although the chance of achieving such a correlation is small becuase of the inadequate labelling of the specimens. It must be concluded that of the specimens located, most, if not all, cannot be regarded as the specimens on which the original descriptions were based. Under the circumstances it would seem best to

assume the total loss of the original herbarium. It is possible that a few genuine holotypes, which survived the fire of 1783 are being dismissed summarily, but in such matters it is better to adopt a cautious attitude than to accept, blindly, all surviving Hudson specimens as original type specimens. Unless a considerable amount of new information is discovered in the future, the historical background of the Hudson herbarium will remain obscure and there will be little hope of distinguishing any genuine type specimens from the remainder of the herbarium. It should be possible to select neotypes from the specimens located, but this selection must be undertaken only after careful and prolonged investigation, not only of the available material, but also of the historical background of the species in question.

At the present time an attempt is being made to prepare a catalogue of the Florideae of *Flora Anglica;* it is hoped that this will be completed in the near future.

JOHN LIGHTFOOT (1735 - 1788).

The botanical collections of John Lightfoot are also of considerable phycological importance in that his *Flora Scotica* (Lightfoot, 1777), the first detailed account of the botany of Scotland, contains numerous original descriptions of algae. As with Hudson's *Flora Anglica*, many of the descriptions are vague, so that determination of Lightfoot's herbarium material is essential, although for a few species the illustrations are sufficiently distinct to permit identification.

Despite numerous statements in the literature that the Lightfoot herbarium was in the Herbarium of the Royal Botanic Gardens, Kew, it was located eventually at the Saffron Walden Museum (Britten, 1915) and only transferred to Kew in 1921. A study of this Lightfoot herbarium, which is kept separate from the general herbarium, showed that it did not contain any algae, fungi or lichens. However, about a dozen algal specimens which had once belonged to Lightfoot were located in the general herbarium at Kew and a further six specimens in the general herbarium at the British Museum (Natural History). An investigation of the history of the collection was instituted and eventually some of the missing sections of the Lightfoot herbarium were located.

The history of the Lightfoot collection is most confused. According to Smith (1812), Lightfoot's herbarium was purchased at his death by King George III for 100 gns., and presented by him to his consort, Queen Charlottee, who was a keen botanist. In 1791, Goodenough obtained permission to examine the herbarium and on finding it in a damaged condition, suggested that it should be looked over by a competent authority. Smith was selected for this task and he made much use of the material in his various botanical works. Goodenough also examined parts of the collection and in his treatment of the *Fuci* (Goodenough and Woodward, 1797) made constant reference to the Lightfoot specimens. It is obvious that Goodenough was permitted to keep a number of the algal specimens; for instance, in the general herbarium at Kew there is a Lightfoot specimen of *Catenella repens* attached to a letter which reads as follows:-

> "Her Majesty is very glad that this little specimen may be of some use to Dr Goodenough, and desires him to keep it. Her Majesty will also give commission to Mr Agnew to search for the fucus which is wanting, in case it had got among other things. Windsor Jan. 4th 1795."

Goodenough obtained also a number of specimens of Angiosperms and it would appear very probable that the earlier reports of the occurrence of the Lightfoot herbarium at Kew are based upon these specimens obtained by Goodenough.

The Lightfoot collection was still in the possession of Queen Charlotte in 1812 (Smith, 1812), but in 1821 the Queen died and the collection was sold, together with many of her other possessions, at Christie's saleroom on June 2nd., 1821. It is thought that these possessions of Queen Charlotte were sold secretly by order of the Prince Regent because of his gambling debts. As Britten (1915) has stated, the conduct of the sale was most peculiar in that the possessions "belonged to someone named 'Queen' .... but it must not be mentioned". The Lightfoot herbarium (Lot 45) "contained in 24 cabinets of fine mahogany" was bought by Robert Brown for the sum of £52 - 10s - 0d. It would appear to have remained in Brown's possession until 1855, for in that year Hooker (1855, p. 341) stated that he had examined a specimen of *Athyrium fontanum* in the "herbarium of John Lightfoot, formerly in the possession of Queen Charlotte, now in that of Mr Brown ....".

The subsequent history of the collection is most obscure. As already stated, Brown died in 1858 and his herbarium passed to J. J. Bennett, who kept the Brown collection in a basement room at the British Museum, where it remained until the death of Bennett in 1876, when it was divided between the British Museum, Kew and the Royal Botanic Garden, Edinburgh. From various statements in the literature (Anon, 1876), it would appear that the Brown collections were more or less inaccessible during the time that Bennett stored them in the British Museum basement, although one or two botanists (i.e. Bentham) had examined portions of them. Britten, who was responsible for the break-up of Bennett's herbarium has stated that no tract could be found, either of a separate Lightfoot herbarium, or of the 24 mahogany cases in which it was stored at the time of the 1821 sale (Britten, 1915). A few isolated Lightfoot specimens were found by Britten at this time, and it is presumed that the six algal specimens from the Lightfoot collection, now in the general herbarium of the British Museum, were acquired in this way. From Britten's remarks it would appear that Brown had disposed of the Lightfoot herbarium at some time between 1855 and his death in 1857.

Boulger (1883) stated in an obituary notice that the Lightfoot herbarium had been in the possession of G. S. Gibson, a banker of Saffron Walden, at the time of his death. Riddelsdell (1905) without giving any reasons, refuted the assertion that Gibson had over possessed the Lightfoot herbarium. Nevertheless after making further inquiries at Saffron Walden, the herbarium was located there and transferred subsequently to Kew. No explanation can be offered to account for the Gibson ownership of the Lightfoot herbarium. A search of the correspondence of Brown (now in the Library of the British Museum) was of no assistance; the only possible clue that has been obtained is that Gibson, during the years 1855 - 1858 (when it is supposed that the herbarium passed out of Brown's possession) was working on his Flora of Essex (Gibson, 1862) in the course of which he examined a number of the classical herbaria. Lightfoot's herbarium is not listed by Gibson among those examined, but this may be due to the fact that it contains few, if any, Essex plants.

As stated previously, the material transferred from Saffron Walden to Kew in 1921 did not contain algae, fungi or lichens. Becuase of the existing confusion, the search for the missing sections of the herbarium proved very laborious. With the assistance of Miss G. Chapman, Curator of the Saffron Walden Museum, a number of parcels of specimens were found at the Museum, which on examination proved to contain the Lightfoot material of the genera *Conferva*, *Fucus* and *Ulva*. Some of the parcels were a little nibbled by mice, but the specimens as a whole are in good condition. This material has now been transferred to the Royal Botanic Gardens, Kew.

The sections of the Lightfoot herbarium dealing with the Fungi and Lichens are still missing and as Lightfoot included a number of algae in his treatment of the fungal genus *Byssus*, this loss is of significance to phycologists. In view of the taxonomic and nomenclatural importance of the problematical sub-aerial *B. purpureus (Rhodochorton purpureum* (Lightf.) Rosenv.), collected originally by Lightfoot on the Abbot Mackinnon's tomb in Iona Cathedral, the search for the missing sections of the herbarium is being continued. It is possible that the missing sections of the herbarium are still hidden at the Saffron Walden, Museum, but no trace of them could be found, despite a careful search.

As stated, the Lightfoot collection as a whole is in a good state of preservation, but it must be realised that the algae of *Flora Scotica* form only a very small part of the whole. The herbarium contains extensive collections from Wales and Cornwall, together with specimens from other parts of the British Isles, many of which were collected by Frankland. In most cases the actual specimens on which the plates of *Flora Scotica* were based have been identified. Without exception the plates are excellent reproductions of the original specimens. In this connection it can be stated that the suggestion of Drew (1955) that the description and figure of *Ulva laciniata* Lightfoot might be based upon a member of the Delesseriaceae is confirmed; a study of the specimen shows that it is a species of the genus *Nitophyllum sensu lato*. This raises considerable difficulties as *P. laciniata* (Lightf.) Ag. is the first species listed by Agardh (1824) in his original treatment of the genus *Porphyra*.

A detailed study of the Florideae of the Lightfoot herbarium has been prepared. Because of the ease with which the majority of type specimens can be identified, typifications is relatively simple. It is proposed to publish this survey in the near future.

I would like to thank the Directors of the British Museum (Natural History) and the Royal Botanic Gardens, Kew, for permission to examine herbarium material; Mr R. Ross, Mrs Y. Butler, Miss C. I. Dickinson and Mr R. D. Meikle for their advice and help with literature and handwriting and Miss G. Chapman for her assistance in the search for the Lightfoot herbarium.

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CHROMOSOME NUMBERS IN THE ALGAE II

CHLOROPHYTA (1)

As the number of records of chromosome counts in the Chlorophyta is so great, it will be necessary to serialise the list. The present records for the Volvocales, Ulotrichales, Cladophorales and Desmidiaceae will be followed by others in later numbers of the Bulletin.

VOLVOCALES

Species	*Chromosome number (n. unless otherwise stated)*	*Authority*
Eudorina unicocca Sm.	7	Cave & Pocock, 1951
E. indica Iyengar	10	Doraiswami, 1940
E. elegans Ehrenb.	10	Hartmann, 1921
"	12	Cave & Pocock, 1951
Gonium pectorale Muell.	17	Cave & Pocock, 1951
Pandorina morum Bory	12	Dangeard, 1900
Pleodorina illinoisensis Kofoid	10	Hovasse, 1937
" "	12	Merton, 1908
P. californica Shaw	c.12	Chalton, 1910
"	14	Cave & Pocock, 1951
Volvox barbari Shaw	5	Cave & Pocock, 1951
V. globator (L) Ehrenb.	5	" " "
V. merilli Shaw	5	" " "
V. africanus West	13	" " "
V. spermatosphaera Powers	13	" " "
V. tertius Meyer	13	" " "
V. aureus Ehrenb.	12	Zimmermann, 1921
"	14	Cave & Pocock, 1951
V. weissmannia Powers	14	" " "
V. powersii (Shaw) Printz	15	" " "
V. gigas Pocock	16	" " "
V. carteri Stein	c.22	Metzner, 1945
Volvulina steinii Playf.	c. 8	Cave & Pocock, 1951
Astrephomene gubernaculifera C. & P.	c. 8	Cave & Pocock, 1956

ULOTRICHALES

Ulothrix zonata	10	Sarma, 1956, 1957; Schussnig, 1930 and Gross, 1931.
U. subtilissima	14	Sarma, 1956, 1957
U. variabilis	7-8	Cholnoky, 1932

Species	*Chromosome number (n. unless otherwise stated)*	*Authority*
U. rorida	5	Lind, 1932
Uronema barlowi	18	Sarma, 1956-1957
U. gigas	18	Sarma, 1956-1957
U. confervicolum	16	Sarma, 1956-1957
U. terrestre	16	Sarma, 1956-1957
Hormidium barlowi	22-24	Sarma, 1956-1957
Hormidium sp.	c. 22	Sarma, 1956-1957
H. crenulatum	44-48	Sarma, 1956-1957
Cylindrocapsa involuta	16-18	Sarma, 1956-1957
Microspora amoena "A"	32	Sarma, 1956-1957
	8-12	Nunstein, 1914
M. amoena "B"	20	Sarma, 1956-1957
	8-12	Nunstein, 1914
M. loefgrenii	18	Sarma, 1956-1957
	14-16	Kostrun, 1955
M. aequabilia	24	Sarma, 1956-1957
M. stagnorum	16	Sarma, 1956-1957
	8-10	Cholnoky, 1932c
M. tumidula	16	Sarma, 1956-1957
Sphaeroplea annulina var. *crassisepta*	16	Sarma, 1956-1957
Sphaeroplea annulina	16	Sarma, 1956-1957
	10	Palik, 1950
Enteromorpha compressa "A"	10 bivalents	
E. compressa var lingulata	10, 2n = 20	Sarma, 1956-1957
E. compressa "B"	9 bivalents	Ramanthan, 1939
E. ramulosa	c. 12	Sarma, 1956-1957
E. intermedia	c. 16	" " "
	10 bivalents)	" " "
	10)	" " "
	12, 2n = 26	Foyn, 1934b
	10	Carter, 1926
	c. 24-25	Levan and Levring, 1942
Prasiola stipitata	12-14	Sarma, 1956-1957
P. japonica	3	Pujiyama, 1955

CLADOPHORALES

Cladophora *Freshwater forms:*		
C. glomerata (1) Kütz	48, 2n = 96	Schussnig, 1954
		Sinha, 1957
" "	30?	Nemec, 1910
	2n? = 68?	T'Serelaes, 1922
	2n? = 64	List, 1930

Species	*Chromosome number (n. unless otherwise stated)*	*Authority*
C. glomerata triploid	3n = 144	Schussnig, 1954
" " forma *genuina*	2n = 72	Geitler, 1936
" " forma *lalliorma*	48	Sinha, 1957
" " subforma *Kutzingiana*	48	Sinha, 1957
C. crispata	24	Sinha, 1957
C. fracta var. *normalis*	2n? = 24	Sinha, 1957
	12	Geitler, 1956
C. alpina	24, 2n = 48	Geitler, 1936
C. II	± 24	" "
C. III	24?	" "
C. IV	30+ , possibly 36	" "
C. V	± 24	" "
C. flexicaulis	12, 2n = 24	" "
Marine forms:		
C. flexuosa	12, 2n = 24	Sinha, 1957
C. Hutchinsine	12, 2n = 24	" "
C. Pellucida	n=± 18 (bivalents)	" "
" "	16, 2n = 32?	Foyn, 1929
C. refracta	12	Sinha, 1957
C. rutentris	24	" "
C. (Aeg.) Linneae	12, 2n = 24	" "
C. Plarescens	12, 2n = 24	Higgins, 1930
Chaetomorpha		
Ch. aerea (marine)	18	Sinha, 1957
	10, 2n = 20	Hartmann, 1929
Ch. linum, attached form (marine)	18	Sinha, 1957
Ch. linum, free floating form (marine)	36	Sinha, 1957
Ch. capillaris (brackish)	18, 2n = 36	Sinha, 1957
Ch. capillaris (marine)	36	Sinha, 1957
Ch. melagonium (brackish)	18	Sinha, 1957
Ch. aerea forma linum (freshwater)	18, 2n = 36	Sinha, 1957
Ch. Henningsii (freshwater)	18	Sinha, 1957
Rhizoclonium		
Rh. riparium (marine)	18, 2n = 36	Sinha, 1957
Rh. riparium (brackish)	36	" "
Rh. riparium (freshwater)	36	" "
Rh. Hockeri (marine)	18	" "
Rh. riparium f. Validum (brackish)	12, 2n = 24	" "
Rh. riparium f. Validum (marine)	24	" "
Rh. implexum (marine)	24	" "
Rh. tortuosum (marine)	24	" "

Species	*Chromosome number (n. unless otherwise stated)*	*Authority*
Rh. hieroglyphicum (freshwater)	24	Sinha, 1957
	24	Geitler, 1936
	30	Peterschilka, 1923
Rh. "Mi"	± 30	Geitler, 1936
Rh. sulfuratum (freshwater)	48	Sinha, 1957
Rh. profundum (freshwater)	approx. 48	" "

CONJUGALES: *Desmidiaceae*

Closterium moniliferum(Bory) Ehrenb.	66	King, 1954
C. acerosum (Schrank) Ehrenb.	60	van Wisselingh, 1912
"A"	c.60	King, 1954
Cosmarium botrytis Menegh.	Clone A 18	King, 1953
	" B 26	" "
	" C c.94	" "
C. cucumis (Corda) Ralfs	44	" "
C. subtumidum Nordst.	24	" "
Cylindrocystis brebisonii Menegh.	c.20	Kaufmann, 1914
" "	c.80	King, 1954
Desmidium swartzii Agardh	c.28	Potthoff, 1927
Gonatozygon monotaenium de Bary	c.29	King, 1954
Hyalotheca dissiliens (Sm.) Breb.	c.12	Acton, 1916
" "	c.112	King, 1953
" "	c.15	Potthoff, 1927
Mesotaenium caldariorum(Lagerh.)Hansg.	c.40	King, 1954
Micrasterias rotata (Grev.) Ralfs	c.172	King, 1954
" "	c.200	Waris, 1950
Netrium digitus(Ehrenb.)Itzigsh & Rothe	32	Maguitt, 1925
" "	c.30	Kopetzky-Rechtperg, 1932
" "	Clone C. c.122	King, 1954
	" M. 172	
	182	" "
" "	Old culture 592	" "
Pleurotaenium trabecula(Ehrenb.) Nag.	104	King, 1953
Sphaerozosma vertebratum Ralfs	c.20	King, 1954
Spondylosium pulchellum Arch.	c.18	" "
Staurastrum gracile Ralfs	c.14	" "

A literature list will be given at the end of the full list of the chromosome numbers of the Chlorophyta.

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M.B.E. Godward

LIST OF MARINE ALGAE FROM THE WEST OF IRELAND COLLECTED BY MEMBERS OF THE THIRD INTERNATIONAL SEAWEED SYMPOSIUM.

A number of field excursions were held during the International Seaweed Symposium from the centre in Galway, Eire, August 13th - 19th. These ranged from Clew Bay in Co. Mayo down to Spanish Point, Co. Clare. In addition, individual members of the Symposium visited other areas as far south as the Dingle Peninsula either before or after the official meeting. Algal records were collected for all of these excursions and are listed below. The lists for the separate divisions were compiled as follows:

Chlorophyta	...	E. M. Burrows
Phaeophyta	...	H. Blackler
Rhodophyta	...	P. S. Dixon
Myxophyta	...	H. T. Powell.

Not all the plants found have yet been identified. For some critical genera (marked with an asterisk) complete specific identification has not been possible in the present state of our knowledge. In the main, the order of species and the nomenclature follow Parke (1953; 1956; 1957). Owing to the difficulty of determining tidal zones in the field on a single short visit, reference in this list of algae is made only to the following approximate regions, supra-littoral, upper and lower mid-littoral and sub-littoral.

For a general description of the areas visited see De Valera (1958). The names of the localities are those given in the Ordnance Maps of Ireland and are numbered as follows:

1. Carrickyvegraly Point, Roonah Quay, Co. Mayo.
2. Garryroe, (nr. Carraroe), Cashla Bay, Co. Galway.
3. Doleen Beaches, (nr. Carraroe), Greatman's Bay, Co. Galway.
4. Spiddal, Co. Galway.
5. Seaweed Point, Salthill, Co. Galway.
6. Between Gratton Road and Mutton Island, Galway, Co. Galway.
7. Galway Harbour.
8. Black Head, Co. Clare.
9. Spanish Point, nr. Milltown Malbay, Co. Clare.
10. Carrerush Point, nr. Milltown Malbay, Co. Clare.
11. Duggerna Rocks, Kilkee, Co. Clare.
12. Bridge of Ross, Co. Clare.
13. Glinn, Co. Limerick.
14. Ballyheigue, Co. Kerry.
15. Fahamore Lagoon, Co. Kerry.

E. M. Burrows
P. S. Dixon

CHLOROPHYTA

Chlorochytrium willei Printz

6. 12. Endophytic in *Blidingia minima;* upper mid-littoral.

Ulothrix flacca (Dillw.) Thur.

4. 6. 8. 14. On the surfaces of boulders and on rock; upper mid-littoral.

Ulothrix pseudoflacca Wille

4. 6. 8. 14. With *Ulothrix flacca;* upper mid-littoral.

Blidingia minima (Näg.) Kylin

1. 3. 6. 7. 12. 13. 14. On rock, on mud and spreading over turf and gravel in quiet places; upper mid-littoral.

Capsosiphon fulvescens (Ag.) Setch. & Gardn.

13. On an old tree trunk at high water mark and on the harbour wall.

Enteromorpha clathrata (Roth.) Grev. sensu Harvey (1851)

1. 3. 4. 12. 15. In pools; mid-littoral.

Enteromorpha compressa (L.) Grev.

1. 2. 3. 4. 6. 8. 10. 11. 12. 14. 15. On rocks and stones and in pools and attached to other algae: also on the backs of limpets and then often grazed to a a close turf; mid-littoral.

Enteromorpha intestinalis (L.) Link

1. 2. 3. 4. 6. 8. 12. 13. 14. 15. On rock and in pools, frequently in the path of freshwater running across the shore; mid-littoral.

Enteromorpha linza (L.) J.Ag.

3. 8. In pools; mid-littoral.

Enteromorpha ramulosa (Sm.) Hook. sensu Harvey (1851)

4. On rock; lower mid-littoral.

Enteromorpha spp. At a number of stations. *

Percusaria percursa (Ag.) Rosenvinge

3. 4. On fine gravel, on rock and lying on mud, mixed with other algae; upper mid-littoral.

Ulva lactuca L.

1. 3. 4. 6. 8. 9. 11. 12. 14. 15. On rock and in pools, epiphytic on other algae; mid-littoral and sub-littoral. Showing great variation in size and texture, large plants in the sub-littoral.

Bolbocoleon piliferum Pringsh.

6. In tissues of *Spermatochnus paradoxus;* drift.

Acrosiphonia centralis (Lyngb.) Kjellm.

4. In pools; mid-littoral.

Chaetomorpha aerea (Dillw.) Kütz. sensu Hamel (1931).

3. In pools; upper mid-littoral.

Chaetomorpha melagonium (Web. et Mohr) Kütz.

1. 3. 4. 6. 12. 14. In pools; lower mid-littoral.

Chaetomorpha sp. Collected at several stations. *

Cladophora hutchinsiae (Dillw.) Kütz.

6. In pools; upper mid-littoral.

Cladophora rupestris (L.) Kütz.

1. 3. 4. 6. 8. 9. 12. 14. 15. On rock, and in pools, abundant; mid-littoral.

Cladophora spp. Each collected at several stations. *

Rhizoclonium spp. Abundant at a number of stations. *

Bryopsis hypnoides Lamour.

1. In a pool on an exposed reef; lower mid-littoral.

Bryopsis plumosa (Huds.) Ag.

1. In clear pools; lower mid-littoral.

Codium fragile (Sur.) Hariot subsp. *atlanticum* (Cotton) Silva.

1. 3. 4. 8. 11. 12. 14. On rock and in pools; mid-littoral; fertile.

Codium fragile (Sur.) Hariot subsp. *tomentosoides* (van Goor) Silva.

4. 6. 8. 14. 15. On rock, in pools and attached to other algae; mid-littoral and sub-littoral; fertile.

Codium tomentosum Stackhouse

1. 8. 9. 10. On rock and in pools; lower mid-littoral; fertile.

PHAEOPHYTA

Acinetospora crinita (Carm.) Kornmann

1. In pools; lower mid-littoral; monospores; epiphytic on *Acrothrix gracilis;* plurilocular sporangia.

Chilionema ocellatum (Kütz.) Kuck.

3. Epiphytic on *Rhodymenia palmata;* lower mid-littoral; unilocular sporangia.

Ectocarpus confervoides (Roth.) Le Jol.

1. 2. 3. 6. 9. 10. Epiphytic on various Phaeophyta; mid-littoral; plurilocular sporangia.

Ectocarpus crouanii Thur.

1. Epiphytic on *Scytosiphon lomentaria;* mid-littoral; plurilocular sporangia.

Ectocarpus draparnaldioides (Crn.) Kjellm.

1. Drift; epiphytic on *Saccorhiza polyschides;* plurilocular sporangia.

Ectocarpus fasciculatus Harv.

1. 2. 3. 9. 10. Epiphytic on various Phaeophyta; lower mid-littoral; plurilocular sporangia.

Ectocarpus holmesii Batt.

1. On the jetty; upper mid-littoral.

Feldmannia simplex (Crn.) Hamel

1. In *Codium fragile* subsp. *atlanticum;* lower mid-littoral; plurilocular sporangia.

Giffordia hinksiae (Harv.) Hamel

1. Drift; epiphytic on *Saccorhiza polyschides.*

Giffordia mitchellae (Harv.) Hamel

1. 9. Lower mid-littoral; plurilocular sporangia.

Herponema solitarium (Sauv.) Hamel

1. Epiphytic on *Dictyota dichotoma;* lower mid-littoral; plurilocular sporangia.

Pylaiella littoralis (L.) Kjellm.

1. 2. 4. 6. 9. 14. Epiphytic on Fucaceae; mid-littoral; unilocular sporangia.

Spongonema tomentosum (Huds.) Kütz.

9. Epiphytic on *Fucus vesiculosus;* mid-littoral; plurilocular sporangia.

Waerniella lucifuga (Kuck.) Kylin

1. 6. On rock; upper mid-littoral.

Lithoderma extensum (Crn.) Hamel

1. On *Patella.*

Ralfsia verrucosa (Aresch.) J. Ag.

1. On *Patella.*

Ascocyclus magni Sauv.

1. On *Zostera.*

Myrionema strangulans Grev.

3. In pools, epiphytic on *Enteromorpha linza;* mid-littoral.

Elachista flaccida (Dillw.) Aresch.

1. 3. Epiphytic on *Cystoseira baccata;* lower mid-littoral; unilocular sporangia. Some plants in winter condition, reduced to gall-like basal disks, with few paraphyses.

Elachista fucicola (Vell.) Aresch. f. *fucicola*

1. 2. 3. 4. 6. 9. 10. Epiphytic on Fucaceae; mid-littoral; unilocular sporangia.

Elachista scutellata (Sm.) Duby

2. 3. 4. 6. 9. 10. Epiphytic on *Himanthalia elongata;* lower mid-littoral; unilocular sporangia.

Cylindrocarpus berkeleyi (Grev.) Crn.

1. 9. On rock and in crevices; upper mid-littoral; unilocular sporangia.

Leathesia difformis (L.) Aresch.

1. 2. 3. 4. 6. 9. 10. 14. In pools; epiphytic on various algae; mid-littoral; unilocular sporangia.

Myriactula rivulariae (Suhr.) J. Feldm.

3. Epiphytic on *Cystoseira baccata;* lower mid-littoral; unilocular sporangia.

Myriactula stellulata (Griff.) Levring

1. Epiphytic on *Asperococcus fistulosus* and *Colpomenia peregrina;* lower mid-littoral; unilocular sporangia.

Chordaria flagelliformis (Müll.) Ag. var *flagelliformis*

1. 3. 4. 6. On rock and in pools; lower mid-littoral; unilocular sporangia.

Eudesme virescens (Carm.) J. Ag.

1. 3. In pools; mid-littoral; unilocular sporangia.

Mesogloia vermiculata (Sm.) Le Jol.

1. 3. In pools; mid-littoral; unilocular sporangia.

Acrothrix gracilis Kylin

1. In pools; lower mid-littoral; unilocular sporangia.

Spermatochnus paradoxus (Roth.) Kütz.

6. Drift; unilocular sporangia.

Stilophora rhizodes (Ehrh.) J. Ag.

1. 3. On Rock, also in pools epiphytic on *Cystoseira baccata;* mid-littoral; unilocular and plurilocular sporangia.

Myriotrichia clavaeformis Harv. var. *clavaeformis*

1. 3. 9. Epiphytic on various algae; mid-littoral; unilocular and plurilocular sporangia.

Desmotrichum undulatum (J. Ag.) Rke.

1. 2. 3. Epiphytic on *Asperococcus bullosus, Colpomenia peregrina* and *Rhodymenia palmata;* mid-littoral.

Litosiphon laminariae (Lyngb.) Harv.

1. In pools, on *Alaria esculenta;* lower mid-littoral.

Litosiphon pusillus (Carm.) Harv.

1. 3. 6. Epiphytic on *Chorda filum* and *Halidrys siliquosa;* lower mid-littoral; unilocular and plurilocular sporangia.

Asperococcus bullosus Lamour.

1. In pools. 2. Sandy pools, plants very large and inflated; mid-littoral,
6. Drift; unilocular sporangia.

Asperococcus compressus Griff. ex Hook.

1. 2. In pools; lower mid-littoral; unilocular sporangia.

Asperococcus fistulosus (Huds.) Hook. f. *fistulosus*

1. 2. 6. 9. 10. In pools, epiphytic on *Cladophora rupestris* and *Fucus* spp.; mid-littoral; unilocular sporangia.

Dictyosiphon foeniculaceus (Huds.) Grev. f. *foeniculaceus*

1. 2. 3. 6. On stones and in pools, also epiphytic; mid-littoral.

Colpomenia peregrina Sauv.

1. 2. 4. 9. In pools and epiphytic; mid-littoral. 6. Drift.

Scytosiphon lomentaria (Lyngb.) Endl. var. *lomentaria*

1. 2. 6. 9. In pools; mid-littoral; plurilocular sporangia.

Haplospora globosa Kjellm.

1. 3. 9. In pools; mid-littoral; monospores and plurilocular sporangia.

Desmarestia aculeata (L.) Lamour.

1. In pools; lower mid-littoral and sub-littoral. 3. Drift.

Desmarestia ligulata (Lightf.) Lamour. var. *ligulata*

1. 9. 10. 15. In pools; lower mid-littoral. 3. Sub-littoral.

Chorda filum (L.) Stackh.

1. 3. 15. Lower mid-littoral and sub-littoral. 2. 6. Drift.

Laminaria digitata (Huds.) Lamour.

1. 3. 4. 8. 9. 10. On rock and in pools; lower mid-littoral and sub-littoral.

Laminaria hyperborea (Gunn.) Fosl.

1. 3. 8. 9. 14. Probably widespread; sub-littoral.

Laminaria saccharina (L.) Lamour.

1. 3. 4. 9. 10. 14. 15. Lower mid-littoral and sub-littoral.

Saccorhiza polyschides (Lightf.) Batt.

1. 3. 9. 10. 15. On rock; sub-littoral and in drift.

Alaria esculenta (L.) Grev.

1. 8. 9. 10. 11. 12. 14. On rock and in pools; lower mid-littoral.

Sphacelaria bipinnata (Kütz.) Sauv.

1. 3. On *Halidrys*, forming large tufts; lower mid-littoral. 6. Large balls in drift; unilocular and plurilocular sporangia.

Sphacelaria britannica Sauv.

1. 6. On rock; upper mid-littoral.

Sphacelaria pennata (Huds.) Lyngb. var. *pennata*

1. Epiphytic on *Saccorhiza polyschides*; sub-littoral; propagules.

Sphacelaria pennata (Huds.) Lyngb. var., *fusca* (Huds.) Irvine

1. In pools, epiphytic on *Corallina officinalis*; lower mid-littoral; propagules.

Sphacelaria radicans (Dillw.) Ag.

6. Probably drift; unilocular sporangia.

Cladostephus spongiosus (Huds.) Ag.

1. 3. 4. 6. On rock and in shallow pools; mid-littoral.

Cladostephus verticillatus (Lightf.) Ag.

3. 6. On rock; lower mid-littoral.

Dictyopteris membranacea (Stackh.) Batt.

1. 3. 9. 14. In pools; mid-littoral and sub-littoral; oogonia.

Dictyota dichotoma (Huds.) Lamour. var. *dichotoma*

1. 3. 4. 6. 9. 10. 14. 15. On rock and in pools, also epiphytic; mid-littoral and sub-littoral; oogonia, antheridia and tetrasporangia. Sometimes finely divided.

Asophyllum nodosum (L.) Le Jol.

1. 2. 3. 4. 6. 15. On rocks and boulders, abundant in sheltered places; mid-littoral.

Ascophyllum nodosum (L.) Le Jol. f. *mackaii*

2. On mud, abundant; mid-littoral.

Fucus distichus L.

11. On rock; lower mid-littoral.

Fucus serratus L.

1. 3. 4. 6. 9. 10. 11. 14. 15. On rock; lower mid-littoral and sub-littoral.
2. Light-coloured plants lying unattached on mud, forming a zone in the lower mid-littoral.

Fucus spiralis L.

1. 2. 3. 4. 6. 8. 9. 10. 11. 12. 14. 15. On rock; upper mid-littoral.

Fucus vesiculosus L.

1. 3. 4. 6. 9. 10. 11. 14. 15. On rock and stones; mid-littoral. 2. Large plants with many vesicles, light in colour.

Fucus vesiculosus L. var. *muscoides* Cotton

2. Cracks and crevices in rock; supralittoral.

Fucus vesiculosus L. f. *linearis* (Huds.) Powell

9. 10. 11. 14. On exposed rock; mid-littoral.

Pelvetia canaliculata (L.) Dene. et Thur.

1. 2. 3. 4. 6. 8. 9. 10. 11. 12. 14. 15. On rock; upper mid-littoral.

Himanthalia elongata (L.) S. F. Gray

1. 3. 4. 6. 8. 9. 10. On rock; lower mid-littoral; fertile.

Bifurcaria rotunda (Huds.) Papenf.

8. 9. 11. Pools; mid-littoral.

Cystoseira baccata (Gmel.) Silva

1. 3. 9. 10. Deep pools, and as drift; lower mid-littoral and sub-littoral.

Cystoseira tamariscifolia (Huds.) Papenf.

3. 14. 15. Pools; lower mid-littoral and sub-littoral.

Halidrys siliquosa (L.) Lyngb.

1. 3. 4. 6. 9. 10. 14. Pools; lower mid-littoral.

RHODOPHYTA

Asterocytis ramosa (Thwaites) Gobi

1. Epiphytic on *Ceramium rubrum*, in pool; lower mid-littoral.

Erythrotrichia bertholdii Batt.

8. Epiphytic on *Codium;* lower mid-littoral.

Bangia fuscopurpurea (Dillw.) Lyngb.

1. 12. On rock; upper mid-littoral.

Porphyra sp.

Abundant at all stations *

Acrochaetium alariae (Jonss.) Born.

12. Epiphytic on *Alaria esculenta;* lower mid-littoral.

Acrochaetium bonnemaisoniae (Batt.) J. & G. Feldm.

3. Endophytic in *Bonnemaisonia asparogoides.*

Acrochaetium endozoicum (Darb.) Batt.

2. 6. In *Flustra* and other bryozoa; drift.

Acrochaetium thuretii (Born.) Collins & Hervey.

6. Epiphytic on various algae, throughout mid-littoral; abundant.

Audouinella membranacea (Magn.) Papenf.

4. On hydroid, in shallow pool; lower mid-littoral.

Rhodochorton floridulum (Dillw.) Näg.

2. 4. 6. 14. Sand- covered rocks; mid-littoral; a few tetrasporangia.

Rhodochorton rothii (Turt.) Näg.

1. In rock crevices; upper mid-littoral.

Helminthocladia calvadosii (Lamour.) Setch.

3. On various species of coralline algae; sub-littoral; carposporophytes.

Helminthora divaricata (Ag.) J. Ag.

1. On gravel; sub-littoral; carposporophytes.

Nemalion sp.

1. 3. 4. 8. 9. 11. 12. 14. Abundant in lower mid-littoral. The specimens showed considerable variation in the degree of branching and all intermediate stages occurred between *N. elminthoides* (Vell.) Batt. and *N. multifidum* (Web. & Mohr.) J. Ag.

Scinaia furcellata (Turn.) Bivona

3. On coralline algae; sub-littoral; carposporophytes.

Gelidium sp.

A considerable number of specimens was collected, but it is not yet possible to name this material accurately. The following entities *sensu* Feldmann & Hamel (1936) were collected:

G. latifolium (Grev.) Born. & Thur.

1. 3. 6. 9. 11. 14. 15. On rock and pools; lower mid-littoral.

G. attenuatum (Turn.) Thur.

3. 9. 11. 15. Deep pools in lower mid-littoral; tetrasporangia.

G. pusillum (Stackh.) Le Jolis

1. 2. 4. 6. 8. 9. 12. 14. On rock; mid-littoral.

G. crinale (Turn.) Lamour.

1. 2. 4. 6. 8. 9. In pools; mid-littoral; tetrasporangia.

G. pulchellum (Turn.) Kütz.

1. 3. 4. 9. 11. 15. In pools; lower mid-littoral; tetrasporangia.

Pterocladia pinnata (Huds.) Papenf.

1. 3. 9. 11. 15. In deep pools; lower mid-littoral.

Petrocelis cruenta J. Ag.

1. On rock; lower mid-littoral.

Furcellaria fastigiata (L.) Lamour.

1. 3. 4. 6. 9. In pools and on rock; low mid-littoral; tetrasporangia.

Halarachnion ligulatum (Woodw.) Kütz.

3. On coralline algae; sub-littoral; carposporophytes.

Catenella repens (Lightf.) Batt.

1. 3. 4. 6. 8. 11. On rock; upper mid-littoral.

Calliblepharis ciliata (Huds.) Kütz.

1. 3. 14. On rock; sub-littoral. 1. 8. On rock and in deep pools; lower mid-littoral.

(Also at 3. 4. 6. 8. as drift).

Calliblepharis lanceolata (Stackh.) Batt.

1. 3. 9. Deep pools; lower mid-littoral.

Cystoclonium purpureum (Huds.) Batt.

1. 3. 4. 6. 9. In pools and on rock; lower mid-littoral.

Plocamium coccineum (Huds.) Lyngb.

1. 3. 4. 9. 15. Sub-littoral and in pools in lower mid-littoral; tetrasporangia and carposporophytes.

Sphaerococcus coronopifolius Stackh.

1. Drift.

Gracilaria verrucosa (Huds.) Papenf.

1. On coralline algae; sub-littoral. 6. On sandy mud; lower mid-littoral; tetrasporangia and carposporophytes.

Ahnfeltia plicata (Huds.) Fries.

1. 3. 4. 8. 9. In pools; lower mid-littoral. 6. On sandy mud; lower mid-littoral.

Phyllophora membranifolia (Good. et Woodw.) J. Ag.

1. 9. Deep pools; lower mid-littoral.

Phyllophora rubens (L.) Grev.

1. 3. Sub-littoral. 9. Deep pool in; lower mid-littoral.

Stenogramme interrupta (Ag.) Mont.

3. On coralline algae in sub-littoral and also in drift.

Chondrus crispus (L.) Stackh.

1. 3. 4. 5. 6. 8. 9. 11. 14. 15. In abundance, occurring in pools and on rock throughout the lower mid-littoral; tetrasporangia and carposporophytes.

Gigartina stellata (Stackh.) Batt.

1. 3. 4. 6. 8. 9. 11. 14. 15. In abundance, occurring on rock and in pools in lower mid-littoral; carposporophytes.

Dilsea carnosa (Schmidel) Kuntze

1. 3. 14. In sub-littoral. 4. On rock in lower mid-littoral. 4. 6. 9. As drift; one plant with carposporophytes collected at 1.

Dudresnaya verticillata (With.) Le Jol.

3. On coralline algae; sub-littoral.

Dumontia incrassata (Müll.) Lamour

1. 3. 4. 6. 8. 9. 12. 15. On rock and pools in mid-littoral; tetrasporangia.

Polyides carpinus (Gunn.) Papenf.

1. 4. 9. 11. 15. Pools in lower mid-littoral; tetrasporangia.

Corallina officinalis L.

1. 3. 4. 8. 9. 11. 14. 15. On rock and in pools through lower mid-littoral and sub-littoral.

Jania rubens (L.) Lamour.

15. In deep pool in lower mid-littoral. 6. As drift.

Lithophyllum fasciculatum Fosl.

3. Sub-littoral, in abundance.

Grateloupia filicina (Wulf.) Ag.

4. Pool in lower mid-littoral.

Halymenia latifolia Crn.

9. As drift.

Callophyllis laciniata (Huds.) Kütz.

1. 3. On rock; sub-littoral. 1. 8. 9. In pools; lower mid-littoral. 4. 5. 6. As drift; carposporophytes.

Kallymenia reniformis (Turn.) J. Ag.

1. 3. On rock and coralline algae; sub-littoral; tetrasporangia.

Holmesella pachyderma (Reinsch) Sturch

6. On *Gracilaria verrucosa;* lower mid-littoral.

Asparagopsis armata Harv.

1. Entangled in other algae in sub-littoral.

(*Falkenbergia rufolanosa* (Harv.) Schm.)

14. Epiphytic on various algae; sub-littoral. 5. As drift.

Bonnemaisonia asparagoides (Woodw.) Ag.

3. In deep pool; lower mid-littoral.

Bonnemaisonia hamifera Hariot

1. On small pebbles and coralline algae; sub-littoral.

(*Trailliella intricata* Batt.)

1. On rock, in crevises; lower mid-littoral.

Chylocladia verticillata (Lightf.) Bliding

6. On boulders, embedded in sand; lower mid-littoral.

Gastroclonium ovatum (Huds.) Papenf.

1. 3. 4. 8. 9. In pools; lower mid-littoral; tetrasporangia.

Lomentaria articulata (Huds.) Lyngb.

1. 2. 3. 4. 6. On rock and boulders, through the mid-littoral; tetrasporangia and carposporophytes.

Lomentaria clavellosa (Turn.) Gaill.

1. 3. 4. 8. 9. Pools in lower mid-littoral. 3. Also in sub-littoral.
6. As drift.

Rhodymenia palmata (L.) Grev.

1. 2. 3. 4. 6. 8. 9. 11. 14. 15. Abundant in the lower mid-littoral and sub-littoral; tetrasporangia.

Aglaothamnion polyspermum (Ag.) Parke

3. Shallow pool; lower mid-littoral.

Antithamnion plumula (Ellis) Thur.

1. 9. Deep pools in lower mid-littoral; tetrasporangia and carposporophytes.

Callithamnion arbuscula (Dillw.) Lyngb.

1. 3. 4. 8. 9. 11. 12. 14. Abundant on rock in lower mid-littoral; tetrasporangia and carposporophytes.

Callithamnion corymbosum (Sm.) Lyngb.

6. On stones, *Zostera* and various algae; tetrasporangia and carposporophytes.

Callithamnion tetragonum (With.) Ag.

3. 8. 9. Epiphytic on various algae; lower mid-littoral.

Ceramium acanthonotum (Carm. ex Harv.) J. Ag.

1. 3. 4. 5. 6. 8. 9. 11. 12. 14. 15. Abundant throughout the mid-littoral; tetrasporangia; spermatangia and carposporophytes.

Ceramium ciliatum (Ellis) Ducluz.

1. 3. 4. 8. 9. 11. 12. 14. 15. Or rock and in pools in lower mid-littoral; tetrasporangia and carposporophytes.

Ceramium diaphanum (Lightf.) Roth

4. 6. 8. 9. 15. Pools in the lower mid-littoral; tetrasporangia.

Ceramium echionotum J. Ag.

1. 3. 4. 5. 8. 11. 15. In pools, often epiphytic on other algae; lower mid-littoral; tetrasporangia.

Ceramium flabelligerum J. Ag.

1. 4. 9. 11. 14. 15. In pools in lower mid-littoral; tetrasporangia.

Ceramium rubrum (Huds.) Ag.

1. 3. 4. 6. 8. 14. Pools in lower mid-littoral; tetrasporangia and carposporophytes.

Ceramium strictum Harv.

6. In drift, on *Zostera*.

Compsothamnion gracillimum (Harv.) Näg.

6. In drift, epiphytic on various algae; tetrasporangia.

Compsothamnion thuyoides (Sm.) Näg.

3. A single plant, epiphytic on *Laminaria hyperborea;* sub-littoral; tetrasporangia.

Corynospora pedicillata (Sm.) J. Ag.

3. 9. On various algae, in pools; lower mid-littoral; monosporangia.

Griffithsia flosculosa (Ellis.) Batt.

1. 3. On stones and coralline algae; sub-littoral. 2. 8. 9. 14. Pools in the lower mid-littoral; tetrasporangia and spermatangia.

Griffithsia corallinoides (L.) Batt.

1. A single specimen, in drift; with tetrasporangia.

Halurus equisetifolius (Light.) Kütz.

3. 9. Pools in the lower mid-littoral; tetrasporangia.

Microcladia glandulosa (Soland.) Grev.

1. A single specimen, in drift.

Plumaria elegans (Bonnem.) Schm.

1. 3. 4. 6. 8. 14. On rock; lower mid-littoral; tetrasporangia, parasporangia and carposporophytes.

Ptilota plumosa (Huds.) Ag.

1. 3. On stipes of *Laminaria hyperborea;* sub-littoral; tetrasporangia.

Spermothamnion sp.

Abundant at a number of localities *.

Sphondylothamnion multifidum (Huds.) Näg.

3. 14. On small stones and coralline algae; sub-littoral.

Spyridia filamentosa (Wulf.) Harv.

2. 6. As drift.

Cryptopleura ramosa (Huds.) Kylin

1. 3. On stipes of *Laminaria hyperborea;* sub-littoral. 4. 8. 9. In pools; lower mid-littoral; tetrasporangia.

Delesseria sanguinea (Huds.) Lamour.

1. 3. 14. 15. On rock and epiphytic on *Laminaria hyperborea;* sub-littoral. 3. 8. 9. 11. Pools; lower mid-littoral.

Hypoglossum woodwardii Kütz.

1. 3. 6. 8. 9. 15. On rock or epiphytic; sub-littoral or in pools in lower mid-littoral; tetrasporangia.

Membranoptera alata (Huds.) Stackh.

1. 3. 4. 9. 15. On rock, occasionally epiphytic; in sub-littoral and mid-littoral.

Nitophyllum sp.

1. 3. 14. 15. Sub-littoral, also as drift at a number of localities *.

Pantoneura angustissima (Turn.) Kylin

1. A single small fragment in drift.

Phycodrys rubens (Huds.) Batt.

1. 3. 4. 9. On rock and epiphytic; sub-littoral, also in pools in lower mid-littoral; tetrasporangia.

Polyneura gmelinii (Grev.) Kylin

3. On coralline algae; sub-littoral, also in drift.

Dasya arbuscula (Dillw.) Ag.

1. 8. 12. On rock, in shallow pools and in crevices in lower mid-littoral. 6. In drift; tetrasporangia.

Heterosiphonia plumosa (Ellis) Batt.

1. 3. 14. On rock or epiphytic; sub-littoral. 3. 4. 6. 8. 9. 15. Pools in lower mid-littoral; tetrasporangia and carposporophytes.

Bostrychia scorpoides (Huds.) Mont.

2. 6. Drift.

Brongniartella byssoides (Goodw., et Wood.) Schm.

3. 6. Drift.

Laurencia hybrida (D.C.) Lenorm. ex Duby

6. On sandy rocks; mid-littoral.

Laurencia obtusa (Huds.) Lamour.

1. 3. 9. 14. 15. In deep pools; lower mid-littoral, and sub-littoral.

Laurencia pinnatifida (Huds.) Lyngb.

1. 2. 3. 4. 5. 6. 8. 9. 11. 12. 14. 15. Abundant in mid-littoral.

Odonthalia dentata (L.) Lyngb.

1. Single small fragment in the drift.

Polysiphonia brodiaei (Dillw.) Grev.

1. 3. 4. 6. 9. 12. On rock and in pools throughout the lower mid-littoral; tetrasporangia, spermatangia and carposporophytes.

Polysiphonia lanosa (L.) Tandy

1. 3. 4. 6. 9. 15. Epiphytic on *Ascophyllum nodosum* or *Fucus* sp., mid-littoral; tetrasporangia present.

Polysiphonia fruticulosa (Wulf.) Spreng.

6. On sandy rocks in lower mid-littoral.

Polysiphonia macrocarpa Harv.

8. 12. On rock, lower mid-littoral; tetransporangia.

Polysiphonia nigrescens (Sm.) Grev.

1. 3. 6. 9. In pools, lower mid-littoral; tetrasporangia and carposporophytes.

Pterosiphonia complanata (Clem.) Fkbg.

10. Pools, lower mid-littoral.

Pterosiphonia parasitica (Huds.) Fkbg.

1. 14. Deep pools, lower mid-littoral.

Rhodomela confervoides (Huds.) Silva

1. 3. 4. 6. 9. 12. 15. Abundant in lower mid-littoral; tetrasporangia.

MYXOPHYTA

Calothrix parasitica (Chauv.) Thur. ex Born. et Flah.

1. Endophytic in *Nemalion multifidum* on exposed reefs; lower mid-littoral.

Rivularia bullata (Poir.) Berk. ex Born. et Flah.

1. 3. On rock and on barnacles (*Chthamalus stellatus*); mid-littoral.

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REVIEWS

KOMÁREK, J. and ETTL, H. Algologische Studien. *Czech. Akad. Sci.* Prague 1958. pp. 358. 41,50 Koruny.

Since the war a flourishing school of freshwater phycologists has arisen in Czeckoslovakia under the leadership and guidance of Professor Bohuslav Fott of the Charles University. This book contains three long papers by two able taxonomists, neither of whom is yet 28 years old.

The first article is by Dr Jiří Komárek: Die taxonomische Revision der planktischen Blaualgen der Tschechoslowakei. I recommend this with delight to all those who, like myself, have struggled with the identification of planktonic Myxophyceae. It is based on the examination of the plankton of several bodies of water at regular intervals for three years as well as occasional samples from many others. Here then we have, in some respects, almost the exact opposite of the approach of Drouet and Daily (Butler Univ. bot. Stud. 12, 1952) which was based on a careful and thorough study of almost all the type material in the world's herbaria. It is not surprising, therefore, that Komárek is unable to agree with some of their views, though this is by no means always the case. Equally his treatment diverges somewhat from that in the monumental flora of Elenkin, Hollerbach, Kossinskaja and Poljansky (Monographia algarum Cyanophycearum aquidulcum et terrestrium in finibus URSS inventarum. Moscow & Leningrad 1936-1949). In general (e.g. see p. 19) his treatment follows Geitler's (Schizophyta. Engler and Prantl Naturl. Pflanzenf. 2 ed. 1, 1942).

It is impossible in this short notice to review this or Ettl's papers in any detail but special mention should be made to Komárek's treatment of *Diplocystis (Microcystis, Anacystis, Clathrocystis* etc. of many authors) and the many planktonic forms of *Anabaena*. Among many details worthy of comment one may be almost amused to find that *Anabaena scheremetievii*, every 'find' of which seems to be the subject of a phycological note, is a "Sehr problematische Art" (p. 122) and surprised to hear that he doubts the existence of *Dactylococcopsis*, though I have several times been told that cells of *Ankistrodesmus* belonged to this genus.

The paper contains a series of drawings and some first class photographs which, for algae so difficult to draw, are of special value.

The articles by Dr Hanuš Ettl are: Zur Kenntnis der Klasse *Volvophyceae* and Einige Bemerkungen zur Systematik der Ordnung *Chlorangiales* Pascher. Again the emphasis is on material collected in Czechoslovakia.

The *Volvophyceae* Ettl divides into *Pyramimonadales* and *Raciborskiellales* for the naked unicellular and colonial forms and, for the walled forms, into *Chlamydomonadales* and *Volvocales*. The *Chlorangiales* he groups in four families - *Characiochloridaceae, Chlorangiaceae, Chlorophysemaceae* and *Hormotilaceae*.

The most valuable part of his first article is the re-organisation of *Chlorogonium* and *Chlamydomonas* on the basis of the number, behaviour and especially, position of the contractile vacuoles. This proceeding makes it necessary to divide *Carteria* into two genera, the second, *Pseudocarteria* Ettl being the quadriflagellate parallel to the amended *Chlorogonium*. Anyone who has tried to answer the unanswerable question 'is this long and thin enough to be a *Chlorogonium* or short and fat enough to be a *Chlamydomonas*' might sigh with relief for a clear-cut character and I agree that the position and number of the contractile vacuoles seems to be constant. Whether this is a natural arrangement seems to me to be immaterial for at present we know so little that the details of the classification of algae are based largely on convenience for identification. Ettl describes a number of new species including I believe the five hundredth of *Chlamydomonas*. I am glad to see that he has not fallen for the temptation of dividing it into other new genera merely because it is so big. That would not add to the 'convenience of identification'.

His second article is about many of the epizooic and epiphytic species which form a bridge between the motile and non-motile volvocine algae. A number of these algae were first described in Korschikov's Ukrainian flora and Skuja's last work on Swedish phytoplankton which were revised in previous numbers of this Bulletin (No. 5 p. 38 and No. 6 p. 42) and Ettl disagrees with a good deal of the nomenclature of both these authors. This paper gives a valuable oversight of what is known about these algae, which are by no means easy to study and so are often overlooked. I hope that one result of this work will be that those to be found in many parts of Britain will receive some attention.

Finally I would like to say a word about Ettl's line drawings. Though these are "etwas schematisch" (p. 19) the position in these groups is almost exactly the reverse of that in the Myxophyceae. It is rarely possible to show the essential diagnostic features in photographs because of the metabolic products present and the complexity of the structure of the chloroplast. An accurate picture of these details is necessary even if it makes it appear that the cell structure is easier to see than in fact is usually the case.

These papers, together with those of several other Czech phycologists, make one hope that one day it may be possible to have a joint session of British and Czech phycological societies.

J. W. G. L.

BOURRELLY, PIERRE. Recherches sur les Chrysophycées: Morphologie, phylogénie, systématique. *Revue Algologique*, Mémoire Hors Série, 1, in-8^{o}, 1957, 412 p., 39 fig., 11 pl. Price 3500fr.

All botanists, particularly phycologists, will welcome this work and will wish to congratulate Dr Bourrelly most sincerely on the publication of his researches on the Chrysophyceae. The work will be a standard reference for this class for many years to come since the very extensive field has been covered so successfully.

As an introductory section Dr Bourrelly deals first with the history of the class and the allied groups Coccolithophorales, Craspedomonadales, Silicoflagellata; and secondly with material and methods, emphasizing most strongly the delicate nature of the majority of the forms belonging to this class and the need for studying them in the living state.

The main section of the work is divided into three parts. The first part is devoted to a detailed study of the comparative morphology and cytology of the class, the class being so defined as to permit the inclusion in it of the Coccolithophorales and the attachment to it of the Craspedomonadales and the Silicoflagellata. In this first part the author reviews, with the help of well annotated illustrations, the main structural types, the morphology of the cell, the mode of life (solitary and colonial), adaptation to the planktonic life and the geographical distribution and ecology.

In the extremely interesting and informative second part Dr Bourrelly gives his views on the phylogeny of the Chrysophyceae and his reasons for modifying the classification of Pascher and for adopting his new classification. At the end of the section he summarizes, in diagrammatic form, his conclusions relating to the Chrysophyceae and closely allied groups suggesting a common ancestor for the Chrysophyceae and Xanthophyceae with the Phaeophyceae and Bacillariophyceae, placing them in one group of the Chromophytes (s.str.) with the Chloromonadophyceae as a link to the second group containing the Euglenophyta and Pyrrophyta. He emphasises, however, the necessity for new studies on the flagellae and pigments of all these classes before it can be known if this hypothesis is true. In fact, the quotation he gives at the start of the second part "It could be so, but certainly was otherwise (Boradine)" indicates his thoughts on this section.

The third part will be of very great help to all botanists and protozoologists, and will be indispensable to those working on freshwater and marine nannoplankton and other micro-plant forms. In this section the new classification is applied to a monographic treatment of all the known genera of the Chrusophyceae. The 175 known genera are divided into eleven orders, while the Craspedomonadales and the Silicoflagellales form two additional orders attached to the Chrysophyceae s.str. with affinities with the Chromulinales but with such a distinct specialization that they are isolated from all the Chrysophyceae s.str.

Dr Bourrelly first defines the thirteen orders giving a key for their determination and a table indicating the phylogenetic relationship between the different orders. He devotes a chapter to each order, first discussing the affinities of the families and genera within the order and giving clear helpful diagrams to illustrate his conclusions. He then defines the families within the order and gives keys for their determination and for the determination of the genera. In all cases he indicates the type family for each order, the type genus for each family and the type species for each genus. There is a short diagnosis for each genus and the species he has found are described in detail and figured on eleven plates. He describes two new genera, 31 new species and a number of new varieties and forms; he also amends 13 genera and, for taxonomic reasons, reduces 24 genera to the synonomy of other genera. In addition he makes new combinations for about 50 species.

The finding in 1957 by Fauré-Frémiet and Rouiller of a second very small internal flagellum in *Chromulina psammobia* will no doubt gladden Dr Bourrelly's heart as it is a valuable discovery to strengthen his hypothesis of the reduction of the acronematic flagellum in the Ochromonadales giving rise eventually to the Chromulinales with only the pleuronematic flagellum remaining (visible?). The placing of the Coccolithophoridaceae as a family in the Ochromonadales can be questioned but further research on the flagella structure and on the life-histories of members of this family will eventually show their true position within the Chrysophyceae.

A very full bibliography is given and an index to the orders, families and genera. Since the memoir was completed early in 1954 a supplementary section with an additional bibliography has been added at the end. In it short notes are given on new information relating to the Chrysophyceae which has been published during 1955 and 1956.

M.P.

TIFFANY, L. H. Algae - The Grass of Many Waters. 2nd Ed. Blackwell Scientific Publications. Price 50/-.

Written for the general reader in a delightfully informal style, it is profusely illustrated and gives a good general survey of the algae which inhabit so many parts of the globe. It should be in all school and public libraries. Changes have been made in this 2nd edition, some of the illustrations are new and an additional chapter has been included on "Algae and research".

M.P.

REPORT: The Freshwater Biological Association: twenty-sixth Annual Report for the year ending 31st March 1958. Pp. 80. Price to non-members 4s 0d.

The report of the director on the scientific work of the staff follows the usual lines. The section on chemistry includes discussion on the amounts of certain 'trace' metals in water and algae. The analyses for cobalt, copper and zinc suggest that "the uptake of such elements by algae may be governed rather by their concentractions in the surrounding water than by any physiological needs of the plant." *Uroglena* from Windermere was found to contain as much as 1300 µg of zinc per gram of dried material.

The experiments carried out during the last three years for a Water Board to determine the probable effects of applying fertilisers, notably basic slag, to the catchment area of their main reservoir have been concluded. The Association reported that it was unlikely that moderate applications of lime and basic slag would result in algal troubles. The Board's restrictions will therefore be relaxed. The Association will continue to examine the phytoplankton of the reservoir for several years to see if any changes result from this increased use of fertilisers.

Many phycologists probably have heard that the acidity of bog waters is caused by humic substances so that the research on these waters and *mor* soils will be of interest to them. It is now believed that the acidity is caused by sulphuric acid which, in Britain, comes largely from industrial pollution as is shown by the analyses of rain also reported here.

The work on cores from lake sediments has been greatly aided by the development of a much improved corer. As a result many more samples from several lakes have been obtained and an almost embrassingly large amount of material is available for pollen and diatom analyses.

Work on the smaller nannoplankton has shown that the most numerous forms belong to the green algae, diatoms and Chrysophyceae. There are no minute Myxophyceae or Xanthophyceae and Peridineae are uncommon. Other phycological investigations have been concerned with the growth of diatoms and green algae in cultures suspended at various depths in Windermere and the routine observations on their seasonal changes in abundance over the last twelve years.

The Fritsch Collection of Illustrations of freshwater algae continues to make good progress; some 18,000 illustrations covering about, 5,000 species being added during the year.

Some of the work on stream algae discussed here has recently been published and the problems raised by these observations now need to be investigated experimentally. Work on polluted streams is also reported and various methods for determining algal growth and light intensities are discussed. The Pollution Research Unit now consists only of the botanist and has been transferred to The Ferry House.

Several years ago the appointment of a plant physiologist was approved and now Dr J. F. Talling has been given the post. He will work on primary production.

In the section devoted to mycology reference is made to species parasitising algae.

After the usual list of papers published during the year, there is a new section listing the limnological papers published in the British Isles in 1957. This should prove of considerable value to phycologists and they will be glad to know that it is intended to make this a regular feature of the annual report.

J.W.G.L.

News Bulletin of the Phycological Society of America: vol. XI. nos. 33 - 35. 1958.

Volume XI of the News Bulletin contains a list of the phycological literature for 1956, in which some 800 references are arranged in alphabetical order. This follows the form adopted for the 1955 list, and therefore the authors have abandoned the division into sectional interests of the earlier lists. With the accumulation of so much data in readily available form, the Phycological Society offers a major contribution to phycologists throughout the world and one for which all interested workers are grateful.

The November number of this volume (no. 35) is given over to an account of the thirteenth annual meeting of the Phycological Society of America, held in conjunction with the convention of the American Institute of Biological Sciences at Indiana University from August 24th.-28th. 1958. A full report is given of the important paper by R. Emerson and R. V. Chalmers on the Function and Phylogenetic Significance of the Accessory Pigments of Algae. And as well, as may be expected in Indiana, there are abstracts of many shorter papers on various aspects of freshwater algae.

British phycologists will note with gratitude the obituary notice of Dr Kathleen M. Drew.

E.C.

LETTERS TO THE EDITOR

A PRELIMINARY LIST OF THE MARINE RHODOPHYTA OF THE SCILLY ISLANDS.

The Isles of Scilly comprise a cluster of five inhabited islands and some one hundred and forty islets in the Atlantic Ocean, twentyfive miles southwest of Lands End. The islands are widely separated, so that the archipelago occupies more than fifty square miles. As is to be expected, the climate of the islands is extremely equable, whilst the seasonal variation in sea temperature is about 5°C. The tidal range is about 7.3 ft. (2.2 m.) at neap tides and 18.3 ft. (5.5 m.) at spring tides.

In view of the situation of the Scilly Islands it is surprising that so little attention has been paid to their marine flora. E. George, whose herbarium is now incorporated in the general herbarium at the British Museum (Natural History), collected extensively in most of the islands in 1899 - 1900 and, in addition, a number of other smaller collections made in the Scillies are preserved in the national herbaria. Batters (1902), in his catalogue of the British marine algae, gives a few records for the Scilly Islands; in all, 32 species and varieties of Rhodophyta are listed. It would appear that these records are based principally on specimens given to Batters by George, but it is obvious also that Batters did not examine the whole of the George herbarium. The George specimens sent to Batters have been incorporated with the Batters collection into the general herbarium at the British Museum, but as Batters relabelled these specimens, it is possible to differentiate between the George specimens which passed through Batters hands and those which were incorporated directly. Holmes (1906), in his account of the marine algae of Cornwall, cites a number of records for the Scilly Islands which appear to be based partly on the George collections. As with Batters, it would appear that Holmes did not examine the whole of George's collection, but only that part which he incorporated, after relabelling, into his own herbarium. The Holmes herbarium is now at the British Museum, which has thus acquired the whole of the George herbarium. Holmes' list is by no means complete, as he omitted those 'species common all round the coasts of Great Britain... to the number of 85', so that for the Scillies, a total of 35 species and varieties of Rhodophyta are listed.

Recently Kay (1955), in a popular account of the Scilly Islands, has given a list of 57 marine algae, of which 34 are Rhodophyta. This list, apart from the numerous mis-spellings of generic and specific epithets, uses the nomenclature of **'Phycologia Britannica'**; it is not clear who was responsible for the preparation of the list or of the present whereabouts of the specimens on which it is based.

The present list of the marine Rhodophyta of the Scilly Islands is based upon the results of a visit to the archipelago in May/June 1958, together with a reconsideration of all the previously collected material now preserved in the national herbaria. Detailed localities have been omitted because of the preliminary nature of the report. Records based upon a personal collection are marked with an asterisk, whilst those based on specimens in the national herbaria are indicated by the standard abbreviations of the **Index Herbariorum.**

I am indebted to the Directors of the British Museum (Natural History) and the Royal Botanic Gardens, Kew, for permission to examine herbarium material.

Goniotrichum elegans (Chauv.) Le Jol. (*)

Erythropeltis discigera var. *flustrae* Batt. (BM)

Erythrotrichia bertholdii Batt. (*, BM)

Erythrotrichia ciliaris (Carm.) Batt. (*)

Porphyra sp. (see note 1)

Bangia fusco-purpurea (Dillw.) Lyng. (*)

Acrochaetium bonnemaisoniae (Batt.) J. et G. Feldm. (*)

Acrochaetium daviesii (Dillw.) Näg. (*)

Acrochaetium secundatum (Lyngb.) Näg. (*)

Acrochaetium virgatulum (Harv.) J. Ag. (*)

Rhodochorton floridulum (Dillw.) Näg. (*, BM)

Rhodochorton rothii (Turt.) Näg. (*)

Helminthora divaricata (Ag.) J. Ag. (BM)

Nemalion elminthoides (Vell.) Batt. (*,BM)

Nemalion multifidum (Web. et Mohr) J. Ag. (*, BM)

Scinaia furcellata (Turn.) Bivona (*, BM)

Gelidium sp. (see note 2)

Pterocladia pinnata (Huds.) Papenf. (*)

Schizymenia dubyi (Chauv.) J. Ag. (*, BM)

Furcellaria fastigiata (L.) Lamour. (*, BM)

Halarachnion ligulatum (Woodw.) Kütz. (*)

Catenella repens (Lightf.) Batt. (*)

Calliblepharis ciliata (Huds.) Kütz. (*, BM)

Calliblepharis lanceolata (Stackh.) Batt. (*, BM)

Cystoclonium purpureum (Huds.) Batt. (*, BM)

Rhodophyllis divaricata (Stackh.) Papenf. (*, BM)

Plocamium coccineum (Huds.) Lyngb. (*, BM)

Sphaerococcus coronopifolius Stackh. (BM)

Gracilaria verrucosa (Huds.) Papenf. (*)

Ahnfeltia plicata (Huds.) Fries (*)

Gymnogongrus griffithsiae (Turn.) Mart. (*)

Phyllophora brodiaei (Turn.) J. Ag. (*)

Phyllophora membranifolia (Good. et Woodw.) J. Ag. (*)

Phyllophora rubens (L.) Grev. (*)

Chondrus crispus (L.) Stackh. (*, BM)

Gigartina pistillata (Gmel.) Stackh. (BM, K)

Gigartina stellata (Stackh.) Batt. (*, BM)

Dilsea carnosa (Schmidel) Kuntze (*)
Dudresnaya verticillata (With.) Le Jol. (*)
Dumontia incrassata (Müll.) Lamour. (*, BM)
Polyides carpinus (Gunn.) Papenf. (*)
Peyssonellia atropurpurea Crn. (BM)
Rhododermis elegans Crn. (BM)
Rhododermis georgii (Batt.) Colins (BM)
Corallina officinalis L. (*, BM, K)
Corallina squamata Ellis (BM)
Jania rubens (L.) Lamour. (*, BM)
Schmitziella endophloea Born. et Batt. (*)
Grateloupia dichotoma J. Ag. (*)
Grateloupia filicina (Wulf.) Ag. (*)
Halymenia latifolia Crn. (*)
Callocolax neglectus Schm. (*, BM)
Callophyllis flabellata Crn. (BM)
Callophyllis laciniata (Huds.) Kütz. (*, BM)
Kallymenia reniformis (Turn.) J. Ag. (*, BM)
Holmsella pachyderma (Reinsch) Sturch (*)
Naccaria wiggii (Turn.) Endl. (*)
Asparogopsis armata Harv. (see note 3) (*)
Bonnemaisonia asparagoides (Woodw.) Ag. (see note 4) (*, BM)
Champia parvula (Ag.) Harv. (*)
Chylocladia verticillata (Lightf.) Bliding (*, BM)
Gastroclonium ovatum (Huds.) Papenf. (*, BM)
Lomentaria articulata (Huds.) Lyngb. (*, BM)
Lomentaria clavellosa (Turn.) Gaill. (*, BM)
Rhodymenia palmata (L.) Grev. (*, BM)
Rhodymenia pseudopalmata (Lamour.) Silva (*, BM)
Aglaothamnion brodiaei (Harv.) G. Feldm. (*)
Aglaothamnion polyspermum (Ag.) Parke (*, BM)
Antithamnion plumula (Ellis) Thur. (*, BM)
Antithamnion sarniense (Lyle) G. Feldm. (*)
Bornetia secundiflora (J. Ag.) Thur. (*)
Callithamnion corymbosum (Sm.) Lyngb. (*, BM)
Callithamnion tetragonum (With.) Ag. (*, BM)
Callithamnion tetricum Ag. (*, BM)

Ceramium acanthonotum (Carm ex Harv.) J. Ag. (*, BM)

Ceramium ciliatum (Ellis) Ducluz. (*, BM)

Ceramium diaphanum (Lightf.) Roth (*)

Ceramium echionotum J. Ag. (BM)

Ceramium flabelligerum J. Ag. (*, BM)

Ceramium rubrum (Huds.) Ag. (*, BM)

Ceramium strictum Harv. (*, BM)

Corynospora pedicellata (Sm.) J. Ag. (*, BM)

Crouania attenuata (Ag.) J. Ag. (*, BM)

Griffithsia corallinoides (L.) Batt. (*, BM)

Griffithsia flosculosa (Ellis) Batt. (*)

Halurus equisetifolius (Lightf.) Kütz. (*, BM)

Microcladia glandulosa (Soland.) Grev. (*, BM)

Plumaria elegans (Bonnem.) Schmitz. (*)

Ptilothamnion pluma (Dillw.) Thur. (*)

Seirospora griffithsiana Harv. (*)

Spermothamnion sp. (see note 1)

Sphondylothamnion multifidum (Huds.) Näg. (BM)

Spyridia filamentosa (Wulf.) Harv. (*)

Apoglossum ruscifolium (Turn.) J. Ag.

Cryptopleura ramosa (Huds.) Kylin (*, BM)

Delesseria sanguinea (Huds.) Lamour. (*, BM)

Hypoglossum woodwardii Kütz. (*, BM)

Membranoptera alata (Huds.) Stackh. (*)

Nitophyllum sp. (see note 1)

Phycodrys rubens (Huds.) Batt. (*, BM)

Polyneura sp. (see note 1)

Dasya arbuscula (Dillw.) Ag. (*, BM)

Heterosiphonia plumosa (Ellis) Batt. (*, BM)

Brogniartella byssoides (Good. et Woodw.) Schm. (*, BM)

Chondria dasyphylla (Woodw.) Ag. (*, BM)

Laurencia hybrida (D.C.) Lenorm. ex Duby (*)

Laurencia pinnatifida (Huds.) Lamour. (*)

Polysiphonia brodiaei (Dillw.) Grev. (BM)

Polysiphonia elongata (Huds.) Harv. (*, BM)

Polysiphonia fruticulosa (Wulf.) Spreng. (*, BM)

Polysiphonia lanosa (L.) Tandy (*)

Polysiphonia macrocarpa Harv. (*, BM)

Polysiphonia nigrescens (Sm.) Grev. (*, BM)

Polysiphonia urceolata (Dillw.) Grev. (*, BM)

Pterosiphonia parasitica (Huds.) Fkbg. (*)

Rhodomela confervoides (Huds.) Silva (*, BM)

Notes:

1) Numerous specimens of the genera *Porphyra, Spermothamnion, Nitophyllum* and *Polyneura* were collected, but because of the uncertain status of the species of these genera and of the bewildering range of form exhibited in the collected material, no attempt to name this material can be made at the present time.

2) A large number of specimens of the genus *Gelidium* was collected; it is not possible to name this material accurately, but the following entities, sensu Feldmann and Hamel (1936), were located: *G. pulchellum, G. crinale, G. pusillum, G. attenuatum, G. latifolium.*

3) The occurence of *Asparagopsis armata* in the Scilly Islands was first reported by Horridge (1951), who collected a few specimens at the south end of Pentle Bay, Tresco. No trace of *Asparagopsis* could be detected in that locality in 1958, but considerably collections were made, using a diving mask, in the channel between Tresco and Bryher, and off Porth Loo, St. Mary's. *Falkenbergia rufolanosa* (Harv.) Schm., hithertoo unreported, occurred extensively in 1958 at a number of localities, in the lower mid-littoral region.

4) No trace of *Hymenoclonium serpens* could be found.

References:

BATTERS, E.A.L., 1902. A catalogue of the British marine algae. *J. Bot., Lond.*, **40**, (Suppl. 2), 1 - 107.

FELDMANN, J. & HAMEL, G., 1936. Floridees de France, VII. Gelidiales. *Rev. algol.*, **9**, 85 - 140.

HOLMES, E.M., 1906. Marine algae *in The Victoria History of the County of Cornwall*, pp. 586, London. (pp. 81 - 90).

HORRIDGE, G.A., 1951. Occurence of *Asparagopsis armata* Harv. on the Scilly Islands. *Nature, Lond.*, **167**, 732 - 3.

KAY, E., 1955. List of seaweeds *in Isles of Flowers*, pp. 297, London. (pp. 288 - 9).

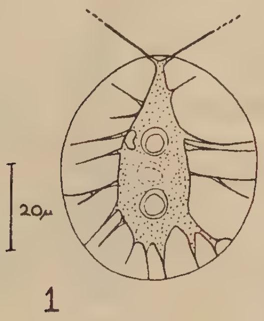
University of Liverpool. P.S. Dixon.

SOME UNCOMMON CHLOROPHYCEAE FROM THE RIVER LEE

Haemotococcus droebakensis.

A form resembling *Haematococcus droebakensis* Wollenweber (*Balticola droebakensis* (Woll.) Droop). appeared in the river near Hoddesdon in May 1958 and individuals were observed sporadically for three to four weeks. It was also seen in the New River at Stoke Newington. This habitat, in water of pH 7.8 - 8.2, contrasts sharply with its previously recorded occurences in small ephemeral pools on acid rock (Droop, 1956). In England it has been found only in hollows on a fallen stone at Stonehenge which has since been re-erected (Pocock, 1951).

Apical papillae have not been seen in the material, but according to Wollenweber (1908) this feature is often difficult to observe. There is a possibility that the cells might be germinating zygotes of *Stephanosphaera*, as these also lack a papilla. However no colonies of the latter have been seen and the likelihood seems remote.



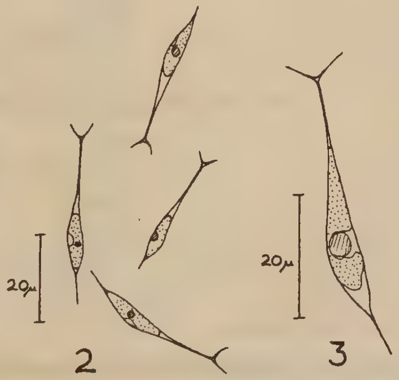


Fig. 1. *Haematococcus droebakensis.* Figs. 2 and 3. *Lambertia* sp.

Lambertia sp.

This free-floating alga was found in the Lee in 19 different collections from July to September 1958. The cells were 30 - 50 µ in overall length, with the basal process occupying one half to one third of the whole. The two small divergent arms on the end of this were 5 - 6 µ long. Some cells were slightly curved, but most of them were straight.

The material was compared with illustrations in the Fritsch Collection at Ferry House and found not to be identical with any species there figured. It was nearest to *L. ocellata* Korsch., but the basal processes are longer and diverge at a wider angle.

There have been a few records of *Lambertia* in Britain, but these are of *L. gracilipes* (Lambert) Korsch. (*Characium gracilipes* Lambert) which is epizootic and of a different shape, and of *L. limnetica* (Lemm.) Korsch. which lacks the two divergent processes.

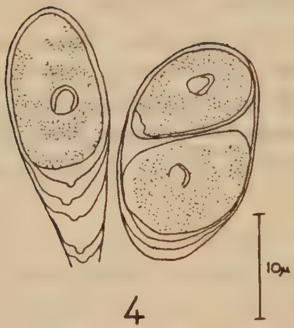


Fig. 4. *Prasinocladus lubricus.*

Prasinocladus lubricus Kuckuck.

This was seen once, in September 1958, at King's Weir, as an epiphyte on the *Chantransia*-stage of *Thorea ramosissima* Bory. The plant is usually an inhabitant of marine and brackish water (Fritsch, 1949), but Smith (1950) says that it can live under preactically freshwater conditions.

I wish to thank Dr J. W. G. Lund and Dr M. R. Droop.

References:

DROOP, M.R., 1956. *Haematococcus pluvialis* and its allies. *Revue Algologique N.S.* 2, 53-71.

FRITSCH, F.E., 1949. Contributions to our knowledge of British Algae. *Hydrobiologia* 1, 115-125.

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SMITH, G.M., 1950. *Freshwater Algae of the United States,* 2nd. Edition. McGraw Hill. (P. 130).

WOLLENWEBER, F., 1908. Untersuchungen über die Algengattung *Haematococcus*. *Ber. deutsch. bot. Ges.* 26, 238.

Sir John Cass College
London.

E. M. F. Swale.

SOME UNCOMMON CHLOROPHYCEAE FROM THE LEE VALLEY

Apistonema pyrenigerum.

Apistonema pyrenigerum Pascher (Pascher, 1931) is a filamentous member of the Chrysophyceae described from damp subterrestrial habitats. It was reported as forming loose irregular filaments, isolated cells also being present. In this condition it was found by Lund (1942) on a damp limestone wall in Yorkshire. However, Waern (1952) collected material from the Baltic which was epiphytic on *Cladophora* and this had better defined filament formation.

During November 1958 abundant material of this species was found epiphytic on *Cladophora* in a gravel pit at Cheshunt in the Lee Valley (National Grid Reference T.L. 369024).

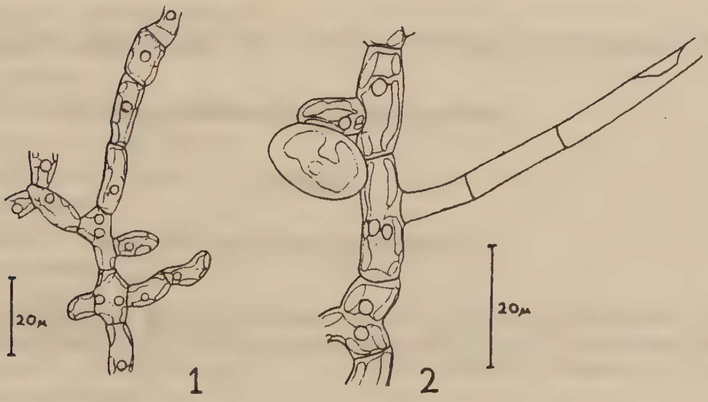

Fig. 1. Filaments of *Apistonema* creeping on the cell wall of *Cladophora*. 2. Cells of *Apistonema* with hair on *Cladophora* with *Cocconeis*.

The filaments were well defined, occasionally leaving the substratum. They were irregular on old *Cladophora* cells covered with *Cocconeis* and other epiphytes, but on new growths of the *Cladophora* they were much more regular in form than Waern's material (figure 1). This formation of filaments is probably related to the submerged habitat. Most of the cells contained two golden yellow chromatophores closely apposed so that it was difficult to tell them apart, but a few cells contained only one. Each cell contained one or two large pyrenoids. Cells averaged 7 μ long by 15 μ broad. Some of the cells bore a tapering multicellular hair, the cells of which still contained the remains of protoplasmic contents (figure 2). These hairs were up to 200 μ in length.

Multicellular hairs of this type do not seem to have been observed before in the Chrysophyceae. *Apistonema* now furnishes a good illustration of the heterotrichous condition in the Chrysotrichales (Fritsch, 1935, p. 554) and of parallel development with the Chaetophorales.

References:

FRITSCH, F.E., 1935. *Structure and Reproduction of the Algae.* 1. Cambridge University Press.

LUND, J.W.G., 1942. Contributions to our knowledge of British Chrysophyceae. *New Phytol.* 41, 274 - 292.

PASCHER, A., 1931. Eine neue braune Fadenalge des Süsswassers (Chrysophyceae). *Arch. Protistenk.* 73, 60 - 72.

WAERN, M., 1952. Rocky-shore algae in the Oregrund Archipelago. *Acta Phytogeograph. Suecica* 30, 1 - 198.

University College, London. J. H. Belcher.

A PRELIMINARY CHECK-LIST OF BRITISH MARINE ALAGAE

Corrections and Additions III

1959

Compiled by Mary Parke

As in Phycological Bulletin no. 4, corrections and new records for the Preliminary Check-List (Parke, 1953) are now recorded. The page numbers quoted refer to the pages of the Check-List.

p.498. Genus *Carteria:* (see Butcher, 1959)

The species list should now read:

depressa Butcher
oliveri West
vectensis Conr. & Kuff.
(= *excavata* Carter non Mass.)

p.498. Genus *Chlamydomonas:* (see Butcher, 1959)

The species list should now read:

brachyura West
bullosa Butcher
coccoides Butcher
gregaria Butcher
nonpulsata Butcher
palla Butcher
pigra Butcher
plethora Butcher
pulsatilla Wohlen
quadrilobata Carter

p.498. Genus *Chlamydomonas* (contd):

rugosa Butcher
semiampla Butcher
spreta Butcher
stagnophila Butcher
subehrenbergii Butcher
tetraolaris Wohlen.
uva-maris Butcher
vectensis Butcher

p.498. Genus *Platymonas*: (see Butcher, 1959)

Delete genus and species and replace by the following:

Tetraselmis Stein, 1878.

(= *Platymonas* West, 1916)

alacris Butcher
apiculata (Butcher) Butcher
carteriiformis Butcher
chui Butcher
contracta (Carter) Butcher
gracilis (Kylin) Butcher
inconspicua Butcher
levis Butcher
maculata Butcher
rubens Butcher
striata Butcher
suecica (Kylin) Butcher
tetrathele (West) Butcher
verrucosa Butcher

p.498. Family Polyblepharidaceae: Butcher (1959) places the genera *Anisomonas*, *Bipedinomonas*, *Nephroselmis* and *Thalassomonas* in the family Pedinomonadaceae but as their systematic position is uncertain they have been left provisionally in the Polyblepharidaceae to avoid major rearrangement.

p.498. Family Polyblepharidaceae: (see Butcher, 1959)

(1) Add before *Bipedinomonas* the following genera and species:

Anisomonas Butcher, 1959.
    longifilis Butcher
Asteromonas Artari, 1913.
    propulsum Butcher

(2) Add after *Bipedinomonas* the following genus and species:

Chloraster Ehrenberg, 1848.
    agilis S. Kent

p.498. Genus *Dunaliella*: (see Butcher, 1959)

Add the following species:

parva Lerche

p.498. Genus *Dunaliella:* (see Butcher, 1959) (contd):

polymorpha Butcher
primolecta Butcher
quartolecta Butcher
tertiolecta Butcher

p.498. Genus *Heteromastix:* (see Butcher, 1959)

Delete genus and species and replace by the following genus and species:

Nephroselmis Stein, 1878.
(= *Heteromastix* Korsch.)

angulata (Korsch.) Skuja
minuta (Carter) Butcher
(= *Heteromastix minuta* Carter)

p.498. Genus *Pyramimonas:* (see Butcher, 1959)

(1) Add the following four species:

disomata Butcher
exigua Butcher
orientalis Butcher
plurioculata Butcher

(2) Add after the genus *Pyramimonas* the following genus and species:

Thalassomonas Butcher, 1959

caeca Butcher
exurgens Butcher
minima Butcher
pusilla Butcher
semiglobata Butcher

p.498. Genus *Codiolum:*

(1) see Kornmann, 1959.

(2) *C.petrocelidis* Kuck. (see Fan, 1957 and Jónsson, 1958)

p.499. Genus *Gomontia:* see Kornmann, 1959, concerning systematic position and life history.

p.499. Genus *Chaetomorpha:* see Christensen, 1958a, concerning *C. aerea* and *C. linum*.

p.500. Genus Rhizoclonium:

(1) see Bliding, 1957.

(2) add following species (Christensen, 1957b): *lubricum* Setch. & Gardn.

p.500. Genus *Urospora:* see Silva, 1957, concerning nomenclature of pleomorphic algae.

p.502. See Corrections and Additions 1953-1955: delete the following section:

Stichogloeales
Stichogloeaceae
Phaeodactylum Bohlin, 1897.
tricornutum Bohlin

Lewin (1958) has revised the taxonomic description of *Phaeodactylum tricornutum* Bohlin and has established within the Bacillariales a new suborder, the Phaeodactylineae, to which *Phaeodactylum* is assigned as the only known genus.

p.502. Genus *Chrysochromulina:* see Additions 1953-1955:

Add following species

chiton Parke & Manton (1958)
strobilus Park & Manton (1959)

p.502. Genus *Apistonema:* record from Dr H. Blacker.

Add following species after *A. carteri:*

pyrenigerum Pascher

p.504. Genus *Stilophora:* see Silva, 1957, p.144.

p.506. Genus *Bifurcaria:* see Ross, 1958.

p.509. Genus *Furcellaria:* see Drew, 1958.

p.510. Genus *Polyides:* see Drew, 1958.
replace species name *caprinus* by *rotundus* (Huds.) Grev.

p.511. Genus *Schmitziella:* from Dr P.S. Dixon - for *endophlaea* read *endophloea*.

p.511. Genus *Bonnemaisonia:* see Silva, 1957, p.143 concerning *B. hamifera*.

p.512. Genus *Ceramium:* from Dr P.S. Dixon - replace
acanthonotum Carm. ex Harv. by
acanthonotum (Carm. ex Harv.) J. Ag.

p.512. Genus *Crouania:* from Dr P.S. Dixon - replace
attenuata (Bonnem.) J. Ag. by
attenuata (Ag.) J. Ag.

p.512. Genus *Halurus:* from Dr P.S. Dixon - replace

equisetifolius (Ag.) Kütz. by
equisetifolius (Lightf.) Kütz.

p.513. Genus *Delesseria:* from Mr J. Ernst - unpublished record for the S.W. coast of England - insert after the genus *Delesseria* the following genus and species:

Drachiella Ernst & J. Feldmann, 1957.
spectabilis Ernst & J. Feldm.

References:

The compiler is grateful to Dr R.W. Butcher for the proof copy of his paper and for allowing her to extract the new records from it so that they could be included in the 1959 Additiona.

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RESEARCH ITEMS

A. THE BIOLOGICAL FLORA OF BRITISH MARINE ALGAE.

A schedule, within the framework of which descriptions for the proposed Biological Flora of British Marine Algae could be prepared, was published in **Phycological Bulletin** No. 2 (1954). After a number of descriptions had been prepared, however, the deficiencies of the schedule became more apparent. On the basis of the experience gained in its use, a revised schedule, published below, has been prepared by the Subcommittee for Marine Algal Check-List and Flora. It is hoped that this new schedule will prove a more adequate basis for work.

SCHEDULE FOR THE DESCRIPTION OF GENERA AND SPECIES FOR THE BIOLOGICAL FLORA OF BRITISH MARINE ALGAE.

This Schedule is only intended to be a guide to information it is essential should be included in the description. Because algal genera and species of different groups show such a great range of variation in structure and in the range of form with habitat, no detailed schedule can be produced which will act as a skeleton for description in all cases. This means that authors must adapt the schedule for their own particular example and allocate information between genus and species description as seems best. However, certain information is essential in all cases and is listed below.

Schedule for the description of a genus for the Biological Flora.

1. **The genus name** with reference to the original description and, if amended, to the amended description, with bibliographical references, dates and authorities and with discussion if necessary.
   All reference to any monographic treatment.

2. **The Type Species of the genus.** The location and the locality of the type specimen. The type specimen of the type species must be seen and checked before this information is included. If necessary a Neotype or Lectotype must be designated.

3. **Synonyms of the genus.**

4. **A description of the genus.** This must cover all described species on a world basis and should include:

   a. A telegraphic description giving essential information for the identification of the genus.
   b. An expanded account of the morphology and anatomy of the thallus including all reproductive structures.
   c. A discussion of characters used in the separation of the species of the genus.

   The balance of information, in this section, between genus and species descriptions, will be dependent on the genus described.

   For genera with more than one species, the genus description cannot be produced until all of the species have been considered.

5. **The range of distribution** both for the British Isles and for the World.
   This may be given in detail if the distribution is clear and concise, but, if it is not, an abstraction only should be included.

   For genera composed of critical species, and in which sub-groupings can be recognised, the distribution of the genus could be summated in terms of the distributions of the sub-groupings.

6. **A key to the species.**
   Here again, for large genera containing critical species, the key may distinguish and characterise sub-groupings. In this case a dichotomous key for one group only need be included in the genus description. (or more than one if worked out.)

Schedule for the description of a species for the Biological Flora.

1. **The name** with reference to the original description and, if amended, to the amended description, with discussion as necessary.

2. **Holotype.** (or Lecto- or Neotype.)

   a. **Location of type** and cotype. The abbreviation should be given as in Index Herbariorum.
   b. **Locality of the type.** Evidence must be given that the type specimen has been checked.

3. **Synonymy.** This should be complete and should be given only after all type specimens have been examined.

4. **Illustration.** Great latitude must be allowed in the choice of illustrations for a species, depending on the type of plant being described.
   Reference to previous illustrations may be given if these are eminently suitable.

5. **Description of the species.** This should include:

   a. Telegraphic description giving information essential for the identification of the species.
   b. Morphological and anatomical description which should refer in general terms to those topics discussed under the genus description, and in detail of topics required particularly for the species.
   c. A bare statement of the lift-history if necessary.
   d. If the life-history is dimorphic, the description of both morphological phases should be given.

   Composite illustrations should be used where possible to clarify and reduce description.

6. **Form range** with a. Level on the shore.
   b. Latitude.

7. **Distribution.**

   a. **British Isles.**
   Maps should be included for those species with a restricted distribution.
   No map should be given for species with a wide distribution; for these only a general statement is required.
   Evidence for distribution must be based on specimens seen and not on records only.

   b. **World.**
   World distribution may be given if it is based on actual specimens of on records accompanied by acceptable illustractions. Special judgement must be used in accordance with the rarity of the species and the difficulty of identification
   Where names of countries are used, these should follow The Times Atlas of the World: Mid-century Edition (ed. by J. Bartholomew) vol. III. 1955.

8. **Habitat.**

   a. **Substrate.**
   b. **Level of occurrence** on the shore and variation with latitude.
   c. **Type of habitat.** Lists of associated species should not be given except in special cases.

9. **Reproduction.**

   a. **Period.**
   b. **Variation** with both level on the shore and with latitude.

10. **Life-history.** A more detailed discussion including, if data are available, the relation between observations under culture conditions and in the field.

11. **Special notes.** e.g. endophytes, fungi, galls, etc.

Offers of work on particular genera and species for the Biological Flora and also for the Check-List and Flora of British Marine Alga, publications being sponsored by the British Phycological Society, will be greatly welcomed by the Subcommittee.

A glossary of terms required in the description of species belonging to the groups of larger algae, *Chlorophyta*, *Phaeophyta* and *Rhodophyta* and any further information concerning these publications may be obtained on application to the Secretary of the Subcommittee.

Hartley Botanical Laboratories,
The University, Liverpool, 3.

E. M. Burrows,
Hon. Sec.

B. ALGAL CULTURES

The following bacteria-free cultures of marine and supra-littoral organisms are now maintained at the Marine Station, Millport, Isle of Cumbrae. The majority are freely available to research workers on application to Dr M.P. Droop at the Station. Applicants are requested to state the nature of their research.

ALGAE

Chlorophyceae.

- *Balticola (Haematococcus) droebakensis*
- *B. beutschlii*
- *Brachiomonas submarina* (+ and - strains)
- *B. submarina* var *pulsifera* (+ and - strains)
- *Chlamydomonas pulsatilla* (2 strains)
- *C. spreta* (+ and - strains)
- *Chlorella ellipsoides*
- *Chlorococcum* sp.
- *Dunaliella salina*
- *D. primolecta*
- *Haematococcus pluvialis* (+ and - strains)
- *Nannochloris oculata*
- *Nannochloris* sp.
- *Platymonas tetrathele*
- *P. carteriaformis*
- *Platymonas* sp.
- *Stephanosphaera pluvialis*

Chrysophyceae.

- *Apistonema* sp.
- *Isochrysis galbana*
- *Monochrysis lutheri*
- *Ochromonas malhamensis*
- *Ochromonas* sp.
- *Prymnesium parvum* (2 strains)
- *Syracosphaera elongata*

Bacillariophyceae.

- *Phaeodactylum tricornutum* (2 strains)
- *Skeletonema costatum*
- *Thalassioscira* (?) *gravida*

Dinophyceae.

Gymnodinium veneficum
Oxyrrhis marina
Peridinium foliaceum
P. trochoideum

Cryptophyceae.

Hemiselmis virescens

Phaeophyceae.

Ectocarpus parasitica
Waerniella lucifuga

Rhodophyceae

Porphyridium cruentum

Porphyridium sp.

YEASTS

Saccharomyces exiguus (not marine)

BRYOPHYTA'A

Amblystegium serpens var. *salinum*

C. REQUEST FOR RESEARCH MATERIAL

Dr I. Friedmann (Department of Botany, The Hebrew University, Jerusalem, Israel) will be glad to receive from October 1959 onwards material of *Prasiola*, marine and freshwater species, from any source. All material should be air-dried and may be posted to Israel in an ordinary letter-envelope. It will be appreciated if marine collections include samples from the top, the middle and the lower parts of the *Prasiola*-zone.

BRITISH PHYCOLOGICAL SOCIETY

Income and Expenditure Account for year ended November 6, 1958.

Expenditure	£.	s.	d.	£.	s.	d.	Income	£.	s.	d.	£.	s.	d.
Bulletin No. 6: Printing (275 copies)	62	-	-				Subscriptions received 1958	106	16	5			
" 50 reprints	2	10	-				*Less* subscriptions received in arrears	9	-	-			
Postage and editor's expenses	6	4	4	70	14	4	*Less* subscriptions received for 1959-61	4	16	4			
							Add subscriptions in arrears for 1958	7	-	-	100	-	1
Postages and stationery				11	15	8	Sale of Bulletins				12	2	6
Expenses of January Meeting				2	-	-	Sale of Reprints				-	3	-
Subscription to Biological Council				-	5	-	Sale of Record Cards				1	1	-
Surplus				28	11	7							
				£113.	6.	7.					£113.	6.	7.

Balance Sheet at November 6, 1958.

Capital & Liabilities	£.	s.	d.	Assets	£.	s.	d.
Capital at November 1st, 1957	187	9	10	Balance at Bank	113	17	9
Subscriptions in advance for 1959-60	4	16	4	On Deposit	100	-	-
Add surplus	28	11	7	Subscriptions in arrears	7	-	-
	£220.	17.	9.		£220.	17.	9.

(Signed) M.T. MARTIN, Hon. Treasurer.

We certify that the above Balance Sheet and Income and Expenditure Account are in accordance with the books and vouchers of the British Phycological Society, which we have duly audited, and in our opinion they give a true and correct view of the transactions of the Society for the period from November 2nd, 1957, to November 6th, 1958, and its position at November 6th, 1958.

W.T. Williams)
(Signed)) Hon. Auditors.
J.K. Spearing)